NUMBER 307

JANUARY–FEBRUARY 2017

TR NEWS

The Promises and Risks of Innovation

Findings from the States

Plus:

The Legal Environment for Driverless Vehicles

Selecting and Prioritizing Freight System Projects

Setting Environmental Performance Measures

Sharing Operations Data: Making the Business Case

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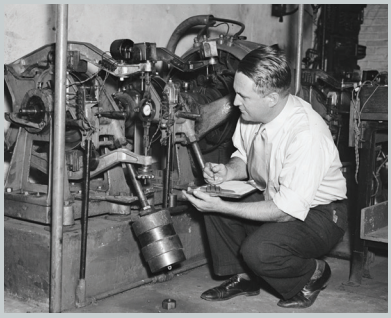

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TR NEWS

features articles on innovative and timely research and development activities in all modes of transportation. Brief news items of interest to the transportation community are also included, along with profiles of transportation professionals, meeting announcements, summaries of new publications, and news of Transportation Research Board activities.

***TR News* is produced by the Transportation Research Board Publications Office**
Javy Awan, Editor and Publications Director
Lea Camarda, Editor
Nick Gass, Assistant Editor
Juanita Green, Production Manager
Michelle Wandres, Graphic Designer

TR News (ISSN 0738-6826) is issued bimonthly by the Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001. Internet address: www.TRB.org.

Editorial Correspondence: By mail to the Publications Office, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001, by telephone 202-334-2972, by fax 202-334-3495, or by e-mail jawan@nas.edu.

Subscriptions: North America: 1 year $60; single issue $12. Overseas: 1 year $85; single issue $12 plus shipping. Inquiries or communications concerning new subscriptions, subscription problems, or single-copy sales should be addressed to the Business Office at the address below, or telephone 202-334-3216, fax 202-334-2519. Periodicals postage paid at Washington, D.C.

Postmaster: Send changes of address to TR News, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001.

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PHOTO: RISDON PHOTOGRAPHY

PHOTO: RISDON PHOTOGRAPHY

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(*Clockwise from top left:*) Former Congressman and past U.S. Secretary of Transportation Norman Y. Mineta addresses an overflow audience after receiving the Frank Turner Medal for Lifetime Achievement in Transportation; two first-time registrants plan out their schedules with apps and printed programs; the Freight Transportation Committee considers its research agenda for 2017.

PHOTO: VIRGINIA DEPARTMENT OF TRANSPORTATION

Once and Future Transportation Innovation

Predicting the Legal Environment for Driverless Vehicles

DOROTHY GLANCY

The author is Professor of Law, Santa Clara University School of Law, Santa Clara, California.

(*Above*:) Driverless vehicle demonstration in Virginia. Are connected and automated vehicle innovations the 21st century equivalents of the horseless carriages of the 19th century?

The legal environment for driverless vehicles will depend in part on the U.S. legal system's responses to earlier transportation innovations. Typically, transformational transportation technologies are presented as modest revisions of previous transportation modes. In the late 19th century, for example, horseless carriages were presented as modifications of familiar conveyances—except for the absence of a horse as the motive force. In the 21st century, driverless vehicles are seen as modifications of a familiar means of transportation—except for the absence of a human operator at the controls.

National Cooperative Highway Research Program (NCHRP) Legal Research Digest 69, *A Look at the Legal Environment for Driverless Vehicles*, reviews ways that the legal order has adapted in the past two centuries to transportation innovations that have transformed mobility (*1*). These innovations also brought new risks to life and limb; eventually, the legal system coped.

Steamboats

After the formation of the United States, steamboats were introduced, enabling brisk travel on the new nation's rivers—but at a price. The vessels' high-pressure boilers were prone to explosions. Bursting boilers were dangerous and often led to the sinking of the ship.

In 1838, 14 boiler explosions resulted in the loss of 496 lives. In one infamous incident, boilers aboard the steamboat *Moselle* exploded before a race on the Ohio River near Cincinnati. The horrific accident

The explosion of the steamboat *Alfred Thomas* near Easton, Pennsylvania, killed a dozen people.

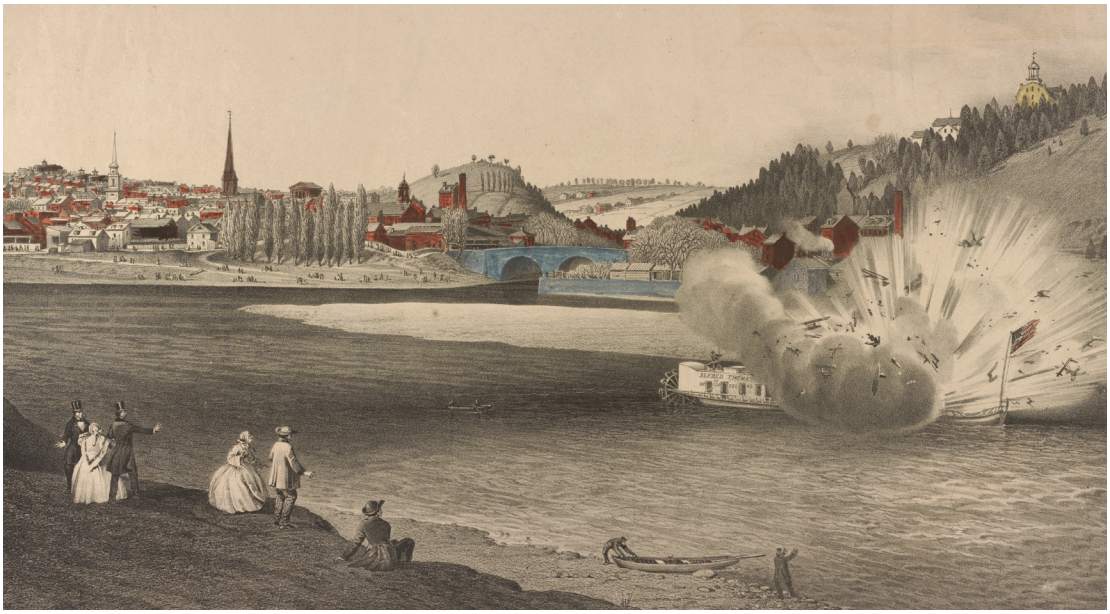


Photo: Library of Congress Prints & Photographs Division

caused approximately 150 deaths; one of the casualties was hurled more than 100 yards and impaled on the roof of a home.

State Actions

Because of the frequency and notoriety of boiler accidents, some states enacted laws to improve steamboat safety. The laws took different approaches, often imposing criminal liability for injuries that resulted from bursting boilers.

Under an 1837 South Carolina statute, a steamboat captain was guilty of a misdemeanor if an exploding boiler caused physical injuries, unless the explosion was shown to be unavoidable. That same year, Illinois passed a slightly more elaborate statute mandating that steamboat boilers and other equipment be "at all times in good and safe order and condition." Masters and owners of boats were jointly and severally liable for damages occasioned by the failure to maintain equipment in good condition. Engaging in steamboat racing was a separate misdemeanor.

Two steamboats and a raft serenely ply the upper Mississippi River, circa 1860. Congress adopted a strict regulatory regime in 1852 to compensate for the ineffectiveness of the earlier federal steamboat laws.

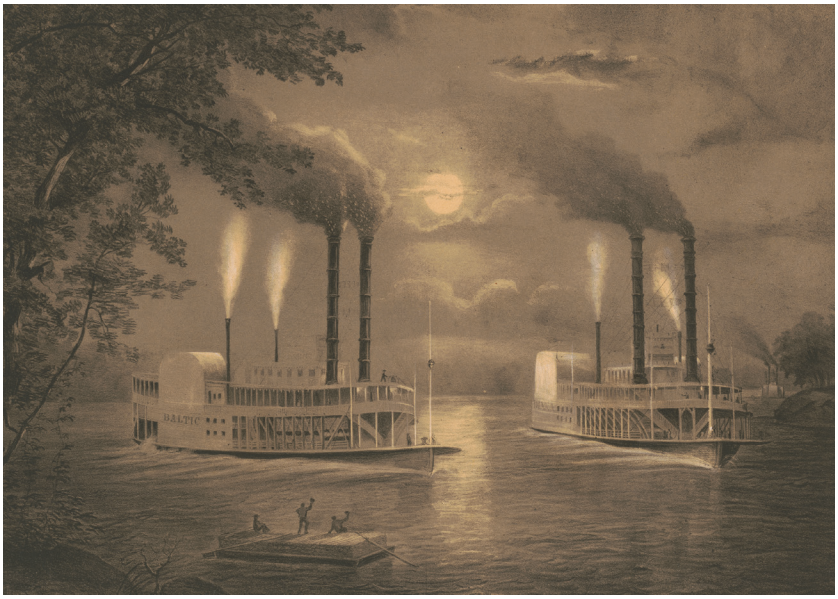


Photo: Library of Congress Prints & Photographs Division

Federal Approach

Proposals to regulate steamboat boilers circulated in Congress as early as 1824. But the the first federal legislation—the Act to Provide for the Better Security of the Lives of Passengers on Board of Vessels Propelled in Whole or in Part by Steam—was not passed until 1838.

The 1838 federal statute took a more comprehensive approach to the problem of bursting boilers than the state laws had. The law established a proactive licensing regime, the prospect of both criminal and civil liability, and inspections. Nevertheless, many of the law's requirements were vague and difficult to enforce.

Shortly after enactment of the federal law, a Cincinnati committee tasked with preparing a report on the *Moselle* disaster complained that the Congressional directives were not specific. The report pointed out that the federal law did not specify design requirements for boilers, such as safety valves or metal walls of specified materials and thickness.

In addition, the new federal inspection program's provision for steamboat owners to pay the inspectors created systemic incentives for lax or nonexistent inspections. Although requiring a "skillful" engineer to be on board, the statute did not define the qualifications—almost anybody could fill the role.

A Stricter Regime

Recognizing the ineffectiveness of the earlier federal steamboat law, Congress adopted a stricter regulatory regime 14 years later. The 1852 statute specified the characteristics and materials required for boilers to pass inspection. The new law was also much more specific about the tests and required independent inspectors to administer the certification process.

These new, more certain requirements took advantage of research on best practices in boiler construction from the Franklin Institute in Philadelphia. The more rigorous, revamped regulatory regime has been credited with the ensuing decline in deaths caused by steamboat boiler explosions. These two steamboat statutes mark the birth of modern safety regulation of transportation technologies.

Railroads

Steamboats introduced federal and state lawmakers to the risks and challenges that can accompany a new transportation technology—but railroads provided the crash course. Railroads began service in the United States in 1830, and the mode's safety risks led to a gradual transformation of the legal system's approach to negligence and civil liability.

Early in railroad history, Americans held positive views about railroads; most people believed that railroad accidents were inevitable and were caused by the misbehavior of railroad management and employees, not by endemic problems with railroad technologies. A spate of railroad accidents in the 1850s, however, brought the riskiness of railroads into sharper focus.

Addressing the Carnage

Between 1850 and 1852, railroads caused an estimated 913 deaths in New York State. Of the persons killed, 321 were railroad employees, 177 were passengers, and 415 were others, such as bystanders or persons struck while walking along the tracks or at crossings.

An editorial in the April 1852 *American Railroad Journal* called on the legal system to address the carnage. Shocked and alarmed by the frequency of railroad "accidents," the editors called for "devising some way of preventing them":

> The only way to prevent accidents is to make it for the interest of railroad companies that they should NOT happen; to make the penalty so great, that freedom from them shall be necessary for economy's sake. … The Legislature should not only see that a proper penalty is annexed to every accident, but the public should take the matter into their own hands by giving exemplary [punitive] damages in all cases that come before a jury.

Pointing to steamboat regulation that imposed standards and inspections, the editors lamented, "The introduction of railroads has been so recent, that legislation has by no means kept pace with their development, nor with the necessity of providing for the public safety."

Crossing the Tracks

Some states enacted requirements that the early railroad companies exercise basic precautions vis-à-vis nonusers, such as persons and livestock crossing over railroad lines. An 1849 Vermont law required railroads to erect fences, install cattle guards at farm crossings, and place signs that warned "Look Out for the Engine" at each road crossing,

Other early state laws regulating rail operations imposed speed limits at crossings and in urban areas. For example, a Mississippi law set a speed

PHOTO: LIBRARY OF CONGRESS PRINTS & PHOTOGRAPHS DIVISION

Railroad disaster in the early 19th century. Editorials in the 1850s called for stricter standards like those introduced for steamboats.

limit of 6 miles per hour for railroads operating within cities and towns.

But state legislatures hesitated to require that railroads replace infrastructure or use particular safety equipment. Congress enacted the first major federal safety law for railroads—the Safety Appliance Act—in 1893, six years after regulating the economics of railroad rates under the Interstate Commerce Act of 1887.

Railroads in the Courts

For most of the 19th century, courtrooms represented the principal forum for presenting and deciding issues of railroad safety. Rail operations were associated with a remarkable variety of accidents and injuries, from derailments and collisions to fires and railyard mishaps away from a moving train.

These episodes produced an unprecedented number of injured plaintiffs suing for tort damages in state courts. The likelihood that a plaintiff would recover losses in an injury case depended in large part on the person's status as a railroad passenger, railroad employee, or someone without a contractual relationship with the railroad.

Standards of Care

When pressing personal injury lawsuits against rail operators, passengers inherited a set of favorable rules that imposed liability without fault on "common carriers" of goods or property. These common carrier liability rules imposed a high—but not absolute—standard of care on railroad companies by presuming that negligence by the carrier caused the crash.

Some states, such as Minnesota, recognized new types of claims that benefited deceased passengers' next of kin and took the first step toward modern "wrongful death" laws. A Massachusetts law enacted in 1840 allowed a deceased passenger's widow or heir to recover between $500 and $5,000 if the negligence or recklessness of a proprietor or employee of a railroad, steamboat, stagecoach, or other common carrier led to the death of the passenger.

Railroad employees and their dependents fared less well in tort lawsuits. Throughout the 1800s, in lawsuits brought by railroad workers, railroad employers successfully invoked three potent defenses—contributory negligence, assumption of risk, and the "fellow servant" rule. The first doctrine barred recovery if the plaintiff's own negligence contributed to the injury; the second defeated a claim if the plaintiff had exposed himself voluntarily to a known risk of harm; and the third exonerated the employer if the injury was the fault of a coworker.

Not until the first decade of the 20th century did Congress address the plight of railroad workers. Legislation abrogated the fellow-servant and contributory-negligence defenses and pared back the assumption-of-the-risk defense in negligence actions brought by railroad employees against their employers.

Trespassers and Turntables

An extensive and complex body of law developed around various patterns in tort lawsuits against railroads. For example, in the 1800s, persons injured after straying onto railroad property often found recovery difficult because the law classified them as "trespassers" to whom the railroads owed no duty of care.

In the mid-1800s, however, courts began to permit recovery if a child had been drawn to trespass

People, horses and carriages, automobiles, and streetcars clog the streets of Des Moines, Iowa, in 1910.

PHOTO: LIBRARY OF CONGRESS PRINTS & PHOTOGRAPHS DIVISION

onto the railroad's premises by a turntable or other equipment perceived as a plaything. These cases created the "turntable doctrine," which became the foundation for the broader tort liability principle commonly known as the "attractive nuisance" rule.

Automobiles

Even before the arrival of motor vehicles in the late 19th century, highway travel was often hazardous. The New York City coroner's report for 1889 counted 12 accidental deaths of people "run over by horse cars," 33 deaths under the heading "run over by cars and engines," and 32 "run over by wagons and trucks." In 1909, the equivalent report still attributed far more transportation deaths to nonmotorized, mostly horse-drawn, vehicles than to automobiles. By 1919, however, automobile fatalities within the city surged to a level several times greater than that associated with horses.

The carnage associated with automobiles continued to climb during the Roaring '20s, when automobile use spiked. By 1929, automobiles were linked to approximately 30,000 deaths annually.

Vehicle Regulations

At first, local governments regulated automobiles; some cities considered banning motor vehicles altogether. For example, in 1899, the Boston, Massachusetts, Board of Aldermen passed an ordinance that would have barred from the city's streets automobiles not expressly endorsed by the aldermen as "not endangering the life or property of others"; the mayor vetoed the ordinance.

As automobiles became increasingly common, state legislatures enacted rudimentary laws for registration, use, and equipment. By 1906, more than half of the states had enacted statutes that called for the registration of motor vehicles with the state, the licensing of automobile operators, the establishment of speed limits, and requirements for simple safety equipment—usually brakes, lamps, and a bell, horn, or other signal.

Early speed limits varied significantly from state to state. In 1903, Alabama adopted a speed limit of 8 miles per hour. At the other extreme, motorists in rural areas of Michigan, Minnesota, and Wisconsin in 1906 could blaze along at up to 25 miles per hour, if their cars were capable.

Crashes and Collisions

Several early statutes focused on how motorists should behave when encountering horses on the roads. The new and often noisy devices tended to frighten horses, but many horses grew accustomed to motor vehicles. Fairly early in the spate of frightened-horse cases, courts found motorists not strictly liable for injuries associated with their machines.

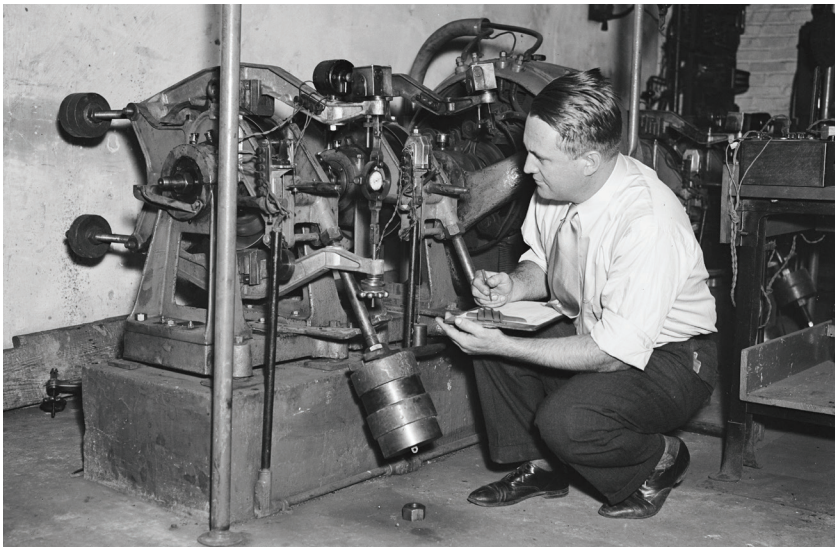


Photo: Library of Congress Prints & Photographs Division

Federal government research sought to determine the efficacy of various brake linings in the early 1930s to reduce automobile-related deaths, which had reached approximately 30,000 by 1929.

Automobile drivers nevertheless had to exercise reasonable care in operating their vehicles around other living beings. Eventually, civil liability claims involving vehicle crashes and collisions were assimilated into the larger body of civil negligence law that had accumulated in relation to carriages and streetcars.

Product Liability

Product liability lawsuits against automobile manufacturers for personal injuries took somewhat longer to appear. A 1906 treatise on automobile law only speculated on the legal rules that would apply to an automobile manufacturer in a lawsuit brought by an injured consumer.

As a practical matter, people injured in early automobile accidents may not have been able to identify what went wrong, much less establish negligent behavior by the automaker. Moreover, prevailing

Photo: Library of Congress Prints & Photographs Division

Speed limits varied by state in the early years of the automobile. At the entrance to Fort Sam Houston in Texas, drivers had to obey a speed limit of 6 miles per hour.

legal rules required "privity of contract" between the persons injured by automobiles and the automobile manufacturers. By 1906, manufacturers already were selling their products through dealer-intermediaries; lack of privity therefore would defeat any lawsuit an injured person might pursue against a manufacturer. In the 1910s, courts began to limit—and eventually eliminated—these privity requirements in negligence cases brought by injured consumers of mass-marketed products, including automobiles.

Accident Litigation

As the number of automobiles surged in the 1920s, the volume of automobile accident litigation also surged. By the late 1920s and early 1930s, tort lawsuits involving automobile crashes constituted 25 percent or more of some urban dockets.

The soaring number of automobile accidents and lawsuits led to second thoughts about the application of negligence principles and courtroom litigation as sensible ways to resolve these incidents. Proposals emerged to replace the vagaries of lawsuits with a more automatic compensation mechanism for injuries associated with automobile crashes. A 1932 Columbia University study of automobile accident litigation concluded:

> The generally prevailing system of providing damages for motor vehicle accidents is inadequate to meet existing conditions. It is based on the principle of liability for fault which is difficult to apply and often socially undesirable in its application; its administration through the courts is costly and slow, and it makes no provision to ensure the financial responsibility of those who are found to be liable.

The Columbia University authors recommended that injuries associated with automobile accidents should come under a no-fault compensation plan modeled after workers' compensation programs. The concept was several decades ahead of its time.

Insurance provided another alternative. The first automobile insurance policy was sold in 1899. After a quarter century, in 1925, Massachusetts became the first state to require vehicle drivers to obtain accident insurance as a prerequisite to operating a motor vehicle on the highways. Nevertheless, other states did not require automobile insurance for another three decades.

Onlookers survey the damage after a small aircraft crashed in front of a store in downtown Minneapolis, Minnesota, in 1919.

PHOTO: LIBRARY OF CONGRESS PRINTS & PHOTOGRAPHS DIVISION

Standardizing Laws

In the 1920s, the federal government convened the National Conference on Street and Highway Safety for representatives of industry, states, and other groups to address traffic safety problems. The 1926 Uniform Vehicle Code sought to standardize disparate state laws and promulgated four model statutes. Many states that were revising their automobile laws quickly adopted portions of the code and the model statutes.

At that time, most injuries associated with automobile accidents were blamed on human error; the rapidly increasing number of automobiles brought new forms of antisocial behavior, such as automobile theft, hit-and-run incidents, and driving while intoxicated. In the 1950s and especially the 1960s, motor vehicle accidents seemed inevitable. As a result, new regulations required automakers to design motor vehicles to reduce occupant injuries in an accident with "passive safety measures."

In 1966, Congress inaugurated the modern era of federal vehicle safety regulation by passing the National Traffic and Motor Vehicle Safety Act, together with the Highway Safety Act. These stat-

utes initiated adoption of federal motor vehicle safety standards, and created an implementing agency known today as the National Highway Traffic Safety Administration.

At the same time, the safety of manufacturers' designs came under scrutiny in the courts. Beginning in the mid-1960s, almost all states recognized that vehicle manufacturing companies could be held strictly liable in tort to injured consumers if unreasonably unsafe product designs led to injuries.

Airplanes

Early in their history, airplanes and aviators had an unfavorable safety reputation. Unfamiliar technologies in early airplanes and the relative novelty of motorized flight seemed to create circumstances that had no legal precedent. Early automobile lawsuits had a large body of decided case law that addressed other highway mishaps, despite the differences in the motive technologies. In contrast, established legal doctrine related to air transportation was scarce.

Protecting Those Below

The primary safety concern associated with early air flight did not involve harm to passengers but danger to those on the ground. Aircraft passengers were regarded as taking risks by venturing into the air. In contrast, injuries to people on the ground, who had not assumed any risks associated with flying, threatened a broader segment of the public.

The principal concern was that a plane might crash on people who were going about their earthbound business. In the early 1910s, Massachusetts and Connecticut enacted statutes that required licensing and registration of aircraft and made aviators liable without fault in an accident.

Common law contained only one famous case on point—*Guille v. Swan*, decided in 1822. A New York City court ruled that a hot air balloonist, who had crashed in the plaintiff's yard, was strictly liable for the ground damage associated with the landing.

This single case provided a slender basis for imposing strict liability for ground damage caused by airplane crashes a century later. Nevertheless, the analogy proved compelling to early legal commentators who regarded motorized air flight as an ultrahazardous activity that offered little social utility but significant peril to bystanders. Criticism of 21st century aerial drones seems to echo similar views.

Enhancing Safety

The federal government became involved in airline safety regulation in 1926, with the Air Commerce Act. The legislation received the endorsement of commercial airline operators, who desired enhanced safety regulation to assure the public that air travel was not as unsafe as the litany of accidents involving barnstormers might have suggested.

The statute delegated to the Secretary of Commerce the responsibility for registering and rating the airworthiness of aircraft, examining airmen for competence, and establishing air traffic rules. These regulatory responsibilities eventually were transferred to the Federal Aviation Administration, the U.S. Department of Transportation agency now tasked with ensuring aircraft safety.

PHOTO: PARADASOS, FLICKR

A driverless shuttle bus in Rotterdam, Netherlands. Increasingly sophisticated driverless vehicles are becoming more commonplace.

Future Policymaking

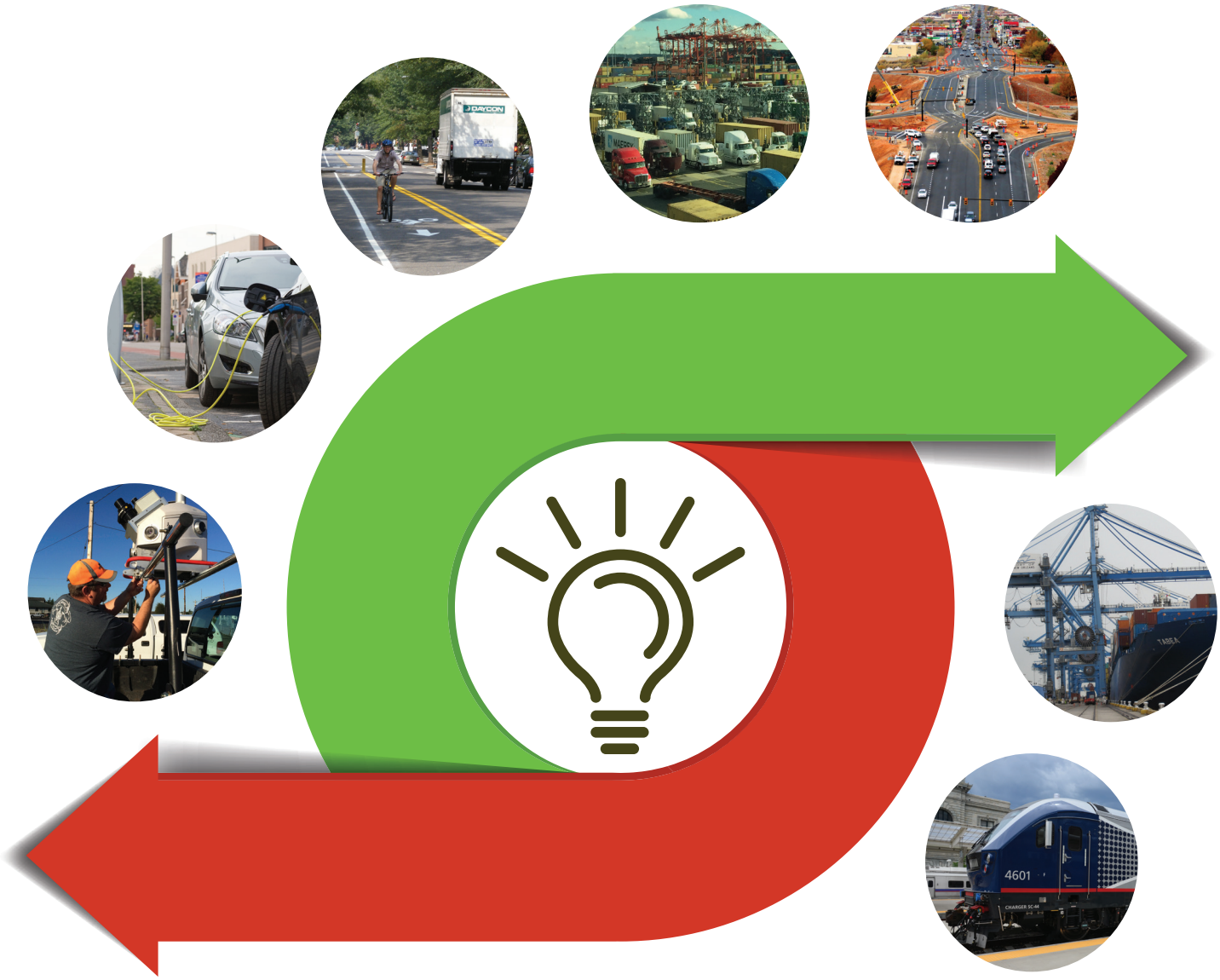
Future policymakers will determine whether some of these echoes from the past will affect legal policies related to more recent technologies, such as driverless vehicles. Past experience with transportation innovations suggests an evolving policy response. Policymaking probably will begin with rudimentary safety measures and later become more complex and far reaching.

At first, the aspects of driverless vehicles that are most suitable for regulation will be defined largely by reference to the laws for conventional vehicles. As driverless vehicles become increasingly sophisticated and common, unprecedented issues—including legal rules on artificial intelligence—will arise that will require innovative and thoughtful responses from policymakers. Some of these responses may produce far-reaching changes in the legal system.

Reference

1. Glancy, D. J., R. W. Peterson, and K. F. Graham. *NCHRP Legal Research Digest 69: A Look at the Legal Environment for Driverless Vehicles*. Transportation Research Board, Washington, D.C., February 2016. www.trb.org/Publications/Blurbs/173557.aspx.

NCHRP Legal Research Digest 69, *A Look at the Legal Environment for Driverless Vehicles*, is available from the TRB online bookstore, https://www.mytrb.org/Store/Product.aspx?ID=8083; to view the publication online, go to www.trb.org/Publications/Blurbs/173557.aspx.



The Promises and Risks of Innovation

Findings from the Transportation Research Board's 2016 State Partnership Visits Program

Specialists in the Transportation Research Board's (TRB's) Technical Activities Division identify current issues, collect and generate information on the issues, and disseminate the information throughout the transportation community. The TRB Annual Meeting, TRB-sponsored conferences and workshops, webinars, standing committee meetings and communications, publications, and contact with hundreds of organizations and thousands of individuals provide TRB staff with information from the public and private sectors on all modes of transportation.

A major source of this information is the TRB annual state partnership visits program. Transportation professionals on the TRB staff meet on site with representatives of state departments of transportation and with representatives of universities, transit and other transportation agencies, and industry. In addition, TRB staff is involved with planning and delivering conferences, workshops, webinars, and meetings. This report summarizes what the TRB staff learned from visits and activities during the past year.

"Transformational" is a word frequently heard among state department of transportation (DOT) officials and technical experts. The word refers to an array of technologies and business models that promise to transform the way transportation is experienced, paid for, and managed. These transformational technologies include connected and automated vehicles, unmanned aerial systems or drones, ride-sourcing services such as Uber and Lyft, big data, and others.

The flip side of this reality is that the word "uncertainty" is also frequently on the lips of transportation professionals. The rapid pace of change is challenging the traditional processes for planning, decision making, construction, operations, and transportation service delivery.

How should transportation agencies estimate future travel demand for their systems? How will the services being offered by companies such as Uber and Lyft change travel behavior and land use? What protections are needed to secure the data and networks for safety and communications? What are the risks, and how should the risks be measured and accounted for in decision making?

The 2016 state visits by TRB senior program officers revealed the energy and insight with which state transportation agencies and their research partners are addressing the promises and challenges of transformational innovations.

Photo: New York City Department of Transportation, Flickr

A New York City DOT–hosted vendor demonstration for the U.S. DOT Connected Vehicle Pilot Program.

Institutional and Cross-Modal Issues

Planning

State DOT and metropolitan planning organization (MPO) officials are focused on practices, performance measures, benchmarks, and goals addressing federal requirements on asset management, safety, and other issues specified in the Fixing America's Surface Transportation (FAST) Act and the Moving Ahead for Progress in the 21st Century Act. At the same time, they are planning for and ensuring consideration of future needs in a rapidly changing environment.

State DOTs and MPOs developing long-range plans and programs seek new approaches and tools for evaluating alternative futures. California DOT (Caltrans), for example, applied scenario planning to prepare the California Transportation Plan 2040, responding to the strict federal performance management requirements, as well as to state laws for the reduction of greenhouse gas emissions.

Many cities demonstrated their commitment to innovation and their willingness to take risks by entering the U.S. DOT Smart Cities Challenge, submitting plans to leverage private-sector and public resources in developing automated vehicle corridors, integrating fleets with connected vehicle technology,

Photo: Larry Levine, WMATA

Workers repair a switch at the Washington, D.C., Metrorail's Twinbrook station, part of the agency's comprehensive, multiphase SafeTrack program to accelerate track work and upgrades.

Researchers at several universities are studying how agencies and the private sector can develop cost-effective transportation networks and systems.

electrifying vehicle fleets, and implementing other innovations. Technical and financial restrictions, however, hinder most organizations from addressing the future uncertainties, particularly with a growing backlog of maintenance needs.

Researchers at several universities are developing models and tools to help agencies and the private sector develop cost-effective transportation networks and systems. Texas A&M Transportation Institute is examining the impacts of a variety of economic scenarios on vehicle miles traveled; the Massachusetts Institute of Technology is exploring the effects of changing economic conditions on freight transportation; and the University of Maryland is testing the impacts of land use, economics, and transportation scenarios on transportation capacity and system needs.

PHOTO: TYSTO, WIKIMEDIA COMMONS

A red-light camera system in Springfield, Ohio. States continue to contend with the legality and constitutionality of automated enforcement, along with the use of unmanned aerial systems and the regulation of ride-sourcing services like Uber and Lyft.

Legal Issues

State DOT attorneys are kept busy with contracts, eminent domain, and other legal matters common to transportation construction and operations, such as the safety of roadside hardware. These attorneys, however, also are addressing critical issues related to transformational technologies.

States are grappling with the legality and constitutionality of automated enforcement, the use of unmanned aerial systems, and the regulation of ride-sourcing services such as Uber and Lyft. Legal opinions on these matters differ among states and among federal agencies, and local governments are playing a key role.

The main challenge is to harness the benefit of new technologies while preserving safety, privacy, and other rights and values. If regulation is too onerous, the benefits may be lost; if regulation is too lax, important rights and values may suffer.

Other critical questions relate to authority and governance: Should new technologies be regulated at the federal, state, or local level? Do these new approaches suggest a shift away from public authority to greater private-sector decision-making? Will new governance structures arise to guide the development of technologies?

Environment, Energy, and Climate Change

States are implementing plans and policies to reduce greenhouse gas emissions and are looking to develop meaningful analyses of the results. The solution includes encouraging the public and other infrastructure stakeholders to get involved in achieving statewide goals. Information contributes to success, but collecting, analyzing, and sharing the right information remains a challenge.

Photo: Bigstock

Electric car charging station, New Rochelle, New York. States are working to maximize benefits from renewable energy, as well as research into vehicle fuel economy; alternative fuel technologies, uses, and infrastructure; and air quality modeling and measurement.

States are looking at research into improvements in vehicle fuel economy; alternative fuel technologies, uses, and infrastructure; and air quality modeling and measurement to achieve statewide goals. Concerted efforts are under way to maximize benefits from renewable energy projects in road rights-of-way, as well as in other state-owned properties and lands.

Data

Improved freight data are a priority as freight flows gain in importance to the economy and to state DOTs. California initiated the Caltrans Truck Survey, modeled after the national Vehicle Inventory and Use Survey that was discontinued in 2002. Caltrans expects the survey results to yield insights on the inventory and flow of commodities and commercial vehicle fleets and to inform statewide freight travel demand modeling, the state's Freight Mobility Plan, and strategies to improve and facilitate freight movement within California.

In Iowa, data on the economy and freight flows are undergoing advanced analysis. Iowa DOT has partnered with the Iowa Economic Development Authority (IEDA) and Quetica, LLC, to develop a comprehensive, demand-based approach to supply-chain optimization for the state, using extremely large volumes of data on global freight movement. The analysis allows IEDA to offer a unique supply-chain design service to firms looking to locate or expand in Iowa. The project exemplifies an increase in state DOTs partnering with other state agencies to develop external data sets of broader interest to the state and its citizens.

Iowa DOT also is working with Iowa State University to apply advanced analytic tools to understand and respond to nonrecurring congestion on the highway network. Advanced tools such as Hadoop open-source software, real-time image processing, and high-performance computing are yielding new insights into the impacts of work zones and incidents.

With increasing interest in bicycle and pedestrian travel, state DOTs are collecting more data and collaborating with others to aggregate data sets, including roadway features, crashes, and usage. Oregon

Photo: Caltrans

Freight traffic in Los Angeles, California. Caltrans expects its latest survey results to yield multiple insights, including strategies to improve freight movement within the state.

PHOTO: NICK FALBO, ALTA PLANNING + DESIGN

A Portland, Oregon, planner's protected intersection concept is tested in Minneapolis, Minnesota. State DOTs are collecting more data and collaborating with other agencies to aggregate data sets on roadway features, crashes, and usage.

DOT maintains large databases related to geometric features, to identify locations of network deficiencies—such as a missing sidewalk or a missing bike lane—and potential safety improvements. The extensive data on crashes involving bicyclists and pedestrians help identify temporal and spatial crash patterns, prioritize locations for investment, and allocate funds for safety programs.

PHOTO: CHRISTINE GERENCHER, TRB

A new dog recruit works with a handler at the Transportation Security Administration's canine training center's mock airport terminal. Only one-quarter of all recruits pass the course.

Aviation

Technology advances in aviation have enabled the evaluation of assistive air traffic management tools in remote or rural locations, the development of new ways to provide more information to the traveling public, and the securing of the entire aviation system from cyberthreats.

Unmanned aerial systems, their potential uses, and their quickly changing regulatory environment continue to attract close interest in the states. Some state DOTs are hiring staff to identify beneficial opportunities that take into account safety and other concerns associated with the rapidly evolving industry.

Freight

The FAST Act, signed into law in December 2015, highlighted the importance of the U.S. freight transportation system. The FAST Act authorized $1.2 billion per year in formula funding for a new National Highway Freight Program, required the establishment of a designated National Highway Freight Network, and authorized a $4.5-billion discretionary competitive grant program to support highway, rail, port, and intermodal freight projects.

To take advantage of the formula funding program, a state must develop a freight plan by December 2017 that "comprehensively [addresses] the state's immediate and long-range freight planning activities and investments." Many states have established freight advisory committees composed of public- and private-sector freight stakeholders to assist in identifying priority areas for freight mobility.

Transportation planners continue to focus on first- and last-mile delivery issues, especially in urban environments. Proposed projects involve off-hours deliveries, lockboxes, and consolidated pickup locations. The City of Seattle has promised $285,000 over the next three years to support the University of Washington's new Urban Freight Lab, which brings together freight carriers and public planning agencies to consider issues and innovative strategies related to urban delivery.

Ports and Waterways

After nine years of construction, a variety of delays, and extensive debate about the changes that would follow, the expanded Panama Canal locks opened in June 2016. East and Gulf Coast seaports and state DOTs already are experiencing the effects, as larger vessels begin to call and increase capacity demands on port infrastructure and freight networks. Ports, states, and MPOs are collaborating to understand and plan for the oncoming effects dockside and beyond.

The New Jersey terminals of Port Elizabeth, Port Newark, and Bayonne comprise the largest load center for freight on the East Coast. Public agencies are collaborating with private terminal operators to optimize and prioritize near-port access projects, anticipating surges in capacity needs from the larger vessel calls. Projects are addressing near-dock rail access, highway ramp capacity improvements, terminal gate optimization practices, terminal productivity measures, and more.

Cargo surges are likely to have a cascading effect on freight network capacity, renewing interest in opportunities for coastal and inland container-on-barge transportation. In October 2016, U.S. DOT awarded $4.85 million in grants to six marine highway projects supporting the twin goals of relieving landside congestion and reducing air emissions. One project, Port of Baton Rouge and Port of New Orleans Container on Barge and Trailer on Barge, supports a new service to provide exporters with a marine alternative for repositioning empty equipment that otherwise would move via truck or rail; the service could eliminate up to 12,500 truck trips each year.

Photo: Scott Brotemarkle, TRB

Trucks and containers at Port Newark, New Jersey, part of the largest load center for freight on the East Coast, along with Port Elizabeth and Bayonne.

Photo: United Soybean Board, Flickr

Containership at the Port of New Orleans, Louisiana.

Photo: Bevis King, Flickr

A Siemens SC-44 Charger at Union Station, Denver, Colorado. The train meets common specifications for locomotives and passenger cars for states that support corridors of less than 500 miles.

Rail

The Passenger Rail Investment and Improvement Act of 2008 called for the states that support short- and medium-haul corridors of less than 500 miles to join together to develop common specifications for locomotives and passenger cars, enabling purchase in quantities at cost savings. The specifications resulted in the development of a new, higher-speed, 125-mph passenger locomotive for state-supported corridors. Deliveries began in 2016 and the new locomotives are undergoing testing. Five states and one private entity have placed orders for more than 75 locomotives.

Railroad traffic continued to decline in 2016, as coal shipments dropped and pipeline construction shifted shipments of crude oil away from rail. Growth in intermodal traffic has made up for some of these losses, and the trend toward containerization has continued—container shipments now outnumber intermodal trailer shipments by more than 10 to 1.

The FAST Act requires state DOTs to create freight plans that address the capacity needs of their networks for handling increases in freight traffic in the next quarter century. Many states are contributing to the construction of new intermodal terminals to increase freight capacity. These terminals not only help to slow the growth of freight traffic on state-maintained highways but become drivers of local and regional economies.

Public Transportation

Transit agencies and state DOTs are evaluating ways to take advantage of transportation network company (TNC) services and are discussing the evolution and potential impact of TNC regulations. A similar discussion involves the effects of connected and automated vehicles (CAVs) on transit and paratransit services. For example, TNCs may fill a useful role at the intersection of transportation and public health, by providing a cost-effective means for disadvantaged populations to travel to and from medical appointments.

State DOTs and transit agencies are adjusting to new technologies. Tennessee DOT, for instance, reorganized its planning department to focus on the management of big data, data visualization, and information graphics. Geographic information systems that communicate schedules and status reports to the public are gaining in use. Interest continues in new bus technology—the Transit Authority of River City in Louisville, Kentucky, is operating an experimental hybrid diesel–electric bus as part of a diesel-free downtown zone, identified with geofencing.

Transit plays a pivotal role at the intersection of health care and transportation. In partnership with the Health and Medicine Division of the National Academies of Sciences, Engineering, and Medicine and with the sponsorship of the Federal Transit Administration (FTA), TRB hosted a workshop on Exploring Data and Metrics of Value at the Intersection of Health Care and Transportation in June 2016. The program was part of FTA's Rides to Wellness initiative.

The TRB Demand-Responsive Transportation Conference in September 2016 continued the theme with a health care track, and the TRB Rural and Intercity Bus Transportation Conference in October also addressed health topics. Tennessee DOT is working with the state's Public Health Department to address the transportation needs of disadvantaged populations.

Photo: Kansas City Regional Transit

The RideKC bus in Kansas City, Missouri, can be summoned and located via smartphone.

Highways

Design

Many state DOTs are using research results to inform roadway design policies, specifications, and practices. Wisconsin DOT, for example, has installed roundabouts successfully at several intersections; detailed technical analysis and sound engineering principles applied to the designs have achieved safe and efficient traffic operations and have reduced congestion. A safety study by the University of Wisconsin Traffic Operations and Safety Lab in 2015 showed that fatal and severe injury crashes had decreased by 40 percent at Wisconsin roundabouts, compared with signalized intersections; the report noted, however, that signalized intersections may be the more appropriate design in many instances.

DOTs have applied research results to design pavement infrastructure incorporating innovative materials and processes and have produced more durable, safe, economical, and environmentally sustainable pavements. Georgia DOT's research on inverted base pavement design sections indicates pavement performance similar to that of conventional pavement sections, but with a potential cost savings of 25 percent.

Missouri DOT and Colorado DOT are designing some pavement sections with warm-mix asphalt to gain environmental and economic benefits. In Louisiana, the Department of Transportation and Development (DOTD) conducted research on open-graded friction courses (OGFCs) for pavement design sections. The OGFC pavements had good macrotexture, with a significant reduction in accidents. Convinced by the performance, Louisiana DOTD has promoted OGFCs for the Interstate Highway System.

PHOTO: DAVE REID, FLICKR

Drivers traverse a new roundabout in Wisconsin.

Construction and Materials

Materials performance has received increased emphasis, to balance in-service distresses and to determine the optimal recycled content. Performance-based specifications and tests for concrete and asphalt are maturing, with state DOTs at different stages of implementation.

New recycling streams from industrial byproducts and biobased additives are challenging agencies

PHOTO: CELESTE HOFFMAN, FLICKR

Workers pour warm-mix asphalt in Washington State. State DOTs are designing pavement sections with the material for environmental and economic benefits.

Photo: Washington State Department of Transportation, Flickr

An excavator removes broken pieces from nearly 50-year-old concrete panels on Interstate 405 in Washington State. Placement of sensors during construction is contributing data for long-life concrete pavements.

to update test methods and to develop advanced, chemistry-based requirements. The in-place recycling of roads is a focal point for states to share best practices on conventional and new materials, construction quality assurance, and comparative studies of performance and economic analyses.

Photo: Vermont Agency of Transportation, Flickr

A construction worker surveys work from below during an accelerated bridge construction in Vermont.

Interests in longevity have spurred the placement of innovative sensors during construction to track performance and contribute to materials selection and construction for long-life concrete pavements. Bridge decks are being developed and specified with high-performance, low-shrinkage concrete mixtures and additives.

Agencies are strengthening asphalt compaction requirements and are using concrete and asphalt additives to improve joints and mitigate the infiltration of water and deicing chemicals. The National Cooperative Highway Research Program (NCHRP) is addressing materials tests for design and quality assurance for long-term resistance to aging and weathering.[1]

Agencies are researching models for estimating construction time and bids for contracting and are comparing accelerated bridge construction under ordinary design–bid–build with design–build approaches. State DOTs are sharing their challenges and successes with alternative project delivery and contracting methods for addressing schedule and cost risks, accommodating disadvantaged business enterprises, and enhancing dispute resolution. Ongoing NCHRP projects are providing agencies with guidance and best practices for these alternative methods.[2]

[1] See http://materials.transportation.org/Documents/Research/NCHRP%20Materials%20Research-July%202016.pdf.

[2] See http://onlinepubs.trb.org/onlinepubs/nchrp/nchrpannual2016.pdf.

Geotechnical Engineering

Unknown subsurface conditions contribute to the financial and technical risks of transportation projects. More than half of state DOTs experience some design, construction, and performance problems from subsurface conditions. Continuing technical advances in instrumentation and modeling, as well as increased experience with new technologies, are enhancing state DOTs' ability to identify potential geotechnical risks and to reduce costs.

LiDAR scanners detect minor movements preceding catastrophic slope failure. South Carolina and Florida DOTs have used thermal integrity profiling to provide quality assurance for drilled shafts and cast-in-place piles. Kansas DOT uses electrical resistivity techniques to supplement and optimize drilling in subsurface investigations. Florida DOT is refining the use of seismic waves to explore subsurface conditions.

Micropiles provide options and cost savings in certain foundation designs and site conditions, as the process becomes more familiar and standardized. Alabama DOT replaced some predrilled H-piles with micropiles on a large Interstate project. Tennessee is using micropiles bonded to bedrock in the construction of the Foothills Parkway.

The geotechnical world is making use of mobile applications, or apps, on smart devices to save time and costs. A Minnesota DOT custom app has improved access to subsurface information in the field in real time.

Geotechnical asset management is gaining recognition as an important part of maintaining and preserving infrastructure. North Carolina DOT and Alaska DOT have established programs to evaluate potential geohazards, reduce risk, and focus maintenance resources in key locations.

Maintenance and Preservation

Maintenance leaders are responding to the rapid developments in automated and connected vehicle technologies and are investigating the potential changes in maintenance practices that may be needed with the deployment of automated vehicle technology. For example, enhanced pavement markings are an area of interest.

Highway maintenance and equipment fleet managers have used automated vehicle location technology for their fleets for more than 20 years. The data help monitor truck location and materials use during winter operations and increasingly are being used to optimize winter maintenance routes, potentially saving public agencies time and resources.

Maintenance divisions at public agencies across the nation are making use of innovative technologies. Handheld data collection devices for recording asset conditions and work quantities have been a particular success. Many agencies also are investigating unmanned aerial systems for bridge inspections, for measuring differentials in surface temperature, and for assessing the general damage after extreme events.

PHOTO: OREGON DEPARTMENT OF TRANSPORTATION, FLICKR

An Oregon DOT technician activates a LiDAR 3-D scanner to detect slope instability.

Operations

The push to improve operations and safety at intersections and interchanges has led state DOTs to explore a range of innovative geometric designs. Successful configurations include diverging diamond interchanges and continuous flow intersections. Utah DOT has implemented these designs in the Salt Lake City area, and many other states are constructing or studying the designs.

Connected and automated vehicles present quickly emerging issues and the potential to spur

Photo: Utah Department of Transportation, Flickr

Drivers navigate a diverging diamond interchange in Utah. State DOTs have explored a range of innovative geometric road designs.

revolutionary change not only for highways but for all transportation modes. The developments have impacts on transportation operations; land use; safety; geometric, pavement, and bridge design; transit and transit operations; freight and goods movements; and more. The the technological advances may take many different paths, but public agencies are exploring the possible impacts on their infrastructure and services, because the technology development will not wait.

The American Association of State Highway and Transportation Officials (AASHTO) recently approved a challenge of deploying dedicated short-range communications (DSRC) infrastructure with signal phase and timing (SPaT) broadcast in at least one corridor in every state by January 2020; a corridor consists of approximately 20 signalized intersections. This challenge includes a commitment to operate the SPaT broadcasts for a minimum of 10 years.

The primary purpose of the SPaT challenge is to provide state and local DOTs with a clear first step toward deploying vehicle-to-infrastructure (V2I) technology and operations and to gain experience with V2I technologies. The challenge provides valuable experience and lessons in the procurement, licensing, installation, and operations of DSRC infrastructure.

Safety

In 2015, the United States experienced the largest percentage increase in crash-related fatalities in nearly 50 years. Preliminary data for 2016 suggest the trend is continuing. Fully automated vehicles offer the promise of significant safety benefits in the future, and some vehicle technologies already are showing value for safety. In the meantime, states are focusing on improving safety through collaborative and data-driven approaches and a mix of infrastructure- and behavior-related countermeasures, with the goal of reaching zero crash-related fatalities.

Utah DOT has established strong relationships with partner agencies to implement the state's Strategic Highway Safety Plan and statewide Zero Fatalities campaign. To enhance data-driven safety decisions, Utah DOT has developed an advanced online analysis tool, which also offers countermeasures for consideration. A user-friendly interface provides various departments in the agency with information on incorporating safety considerations into investment decisions.

District DOT, Washington, D.C., is playing a lead role in the mayor's Vision Zero initiative to reach

Photo: District Department of Transportation, Flickr

A bicyclist rides against the flow of vehicular traffic in Washington, D.C. District DOT is leading the mayor's initiative to reach zero fatalities or serious injuries to travelers in the city's transportation system by 2024. The effort focuses on near-term strategies, including safety improvements for pedestrians and bicyclists.

zero fatalities and serious injuries to travelers in the district's transportation system by 2024. The initiative involves more effective use of data, education, enforcement, and engineering, with a focus on some of the most urgent near-term strategies, such as safety improvements for pedestrians and bicyclists. These initiatives also contribute to another goal—to have 75 percent of all commuter trips via bicycle, walking, or transit by 2032.

SHRP 2

Implementation

When TRB completed the research and development phase of the second Strategic Highway Research Program (SHRP 2) in 2015, FHWA and AASHTO assumed the responsibility for the implementation of the products by state DOTs and other agencies. States are actively testing and adopting more than 60 SHRP 2 products, and FHWA reports that more than 430 implementation projects are in progress across the country.

All but a few projects in the $200 million research program produced usable results—a testimony to the effectiveness of TRB's approach to research management, which involves close cooperation with the ultimate users in state DOTs and other agencies and organizations.

SHRP 2 Safety Data

The safety focus area of SHRP 2 produced an unprecedented amount and variety of data on driving behavior, vehicle and roadway characteristics, and environmental factors through the SHRP 2 Naturalistic Driving Study (NDS). The NDS monitored more than 3,500 volunteer drivers in instrumented cars that traveled 5.4 million vehicle miles.

The companion Roadway Information Database (RID) contains detailed roadway data collected on 25,500 miles of highways in and around the study sites, approximately 200,000 highway miles of data from highway inventories, and data on crash histories, traffic and weather conditions, and work zones in the study sites. The NDS and RID data can be linked to associate driving behavior and outcomes with the roadway environment.

Use of the SHRP 2 safety data is growing. Through the InSight website,[3] researchers can review the data elements, conduct preliminary analyses, and download a training data set. Researchers can request an InDepth dataset for more complex analyses; more than 150 InDepth data use licenses have been issued since April 2015.

FHWA, in conjunction with AASHTO, is sponsoring nine states and 10 university research projects that are using the data, and approximately 20 state DOTs also are working with the data, often with a university partner. Other users include automobile manufacturers, insurance companies, and research firms.

Research topics are varied and include developing analysis tools, run-off-the-road accidents, younger and older drivers, car following behavior, and the safety systems and designs of automated vehicles. Researchers have published 46 papers and submitted 28 for presentation at the 2017 TRB Annual Meeting.

[3] www.insight.shrp2nds.us.

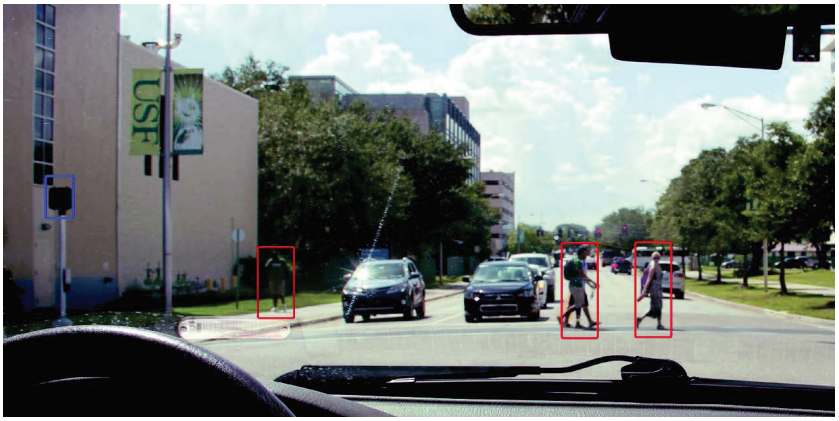


PHOTO: COURTESY OF CUTR AT THE UNIVERSITY OF SOUTH FLORIDA

Pedestrians are detected at a signalized intersection using a video processing method developed by researchers at the Center for Urban Transportation Research (CUTR), University of South Florida. The tool assists in analyzing interactions between drivers and pedestrians at signalized intersections, using videos in the SHRP 2 Naturalistic Driving Study database.

Hope and Enthusiasm

Although the uncertainties identified in this summary are unlikely to be resolved soon, clearly state transportation agencies and their partners are addressing the challenges directly, with hope and enthusiasm for the expected improvements in the movement of people and goods.

Did You Know?

◆ Minnesota DOT established one of the nation's first freight advisory committees in 1998.

◆ Forty-one states, including 16 state capitals and all states east of the Mississippi River, are served by commercially navigable waterways.

PHOTO: VIV LYNCH, FLICKR

A barge on the Cumberland River near Nashville, Tennessee, one of many state capitals served by a commercially navigable waterway.

PHOTO: SEATTLE DEPARTMENT OF TRANSPORTATION, FLICKR

Freight Project Selection and Prioritization

From Identifying the Need to Making the Investment

KEITH J. BUCKLEW

The author is Principal and Freight Practice Leader, HDR, Inc., Fishers, Indiana.

(*Above:*) Freight trucks and automobiles pass near the Port of Seattle, Washington.

Good planning leads to better project selection and ultimately to better strategic transportation investments. Many state departments of transportation (DOTs) and metropolitan planning organizations (MPOs) have focused on creating actionable plans in preparation for the expected increase in federal funding for freight transportation projects.

What constitutes a freight project? To some, almost any project can be labeled a freight project—if a truck can drive through the project limits, then the project supports freight mobility. A more specific definition would note that a freight project supports the efficient, reliable, and safe movement of goods and commodities.

But that definition, too, falls short. The primary purpose of a project determines its support of freight mobility; therefore, according to the definition endorsed by Florida DOT (see Figure 1, right), the project's purpose should be

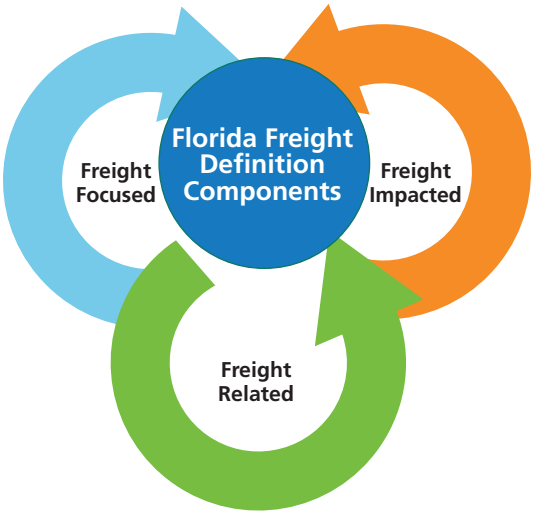


FIGURE 1 Components of Florida DOT's definition of freight.

◆ **Freight focused**, addressing a specific freight transportation need;

◆ **Freight related**, addressing multiple transportation concerns, including freight; and

◆ **Freight impacting**, addressing general transportation needs, but with positive effects on freight mobility.

Four Case Studies

After identifying a freight project, planners must develop a methodology to integrate the project into an overall implementation plan. Four case studies—from Florida, Missouri, Pennsylvania, and Texas—illustrate this approach.

In general, each of these states recognized that an overwhelming volume of freight moved on its highways, which are the primary focus of a state DOT. The states also recognized that funding mechanisms, funding sources, and legislation often limited the state DOT's ability to improve other freight modes. All four states recognized the importance of rail, waterways, air, and pipelines as components of a freight system.

Involving all freight modes, however, went beyond the provisions in the funding authorization legislation then in effect, the Moving Ahead for Progress in the 21st Century (MAP-21) Act. Nevertheless, the states incorporated all freight modes into their project selection and prioritization processes. Each anticipated the multimodal requirements in the next reauthorization bill, the Fixing America's Surface Transportation Act, passed in December 2015. Each state recognized that all freight transportation modes are needed to support economic development.

Florida: Multistep Process

With its Freight Mobility and Trade Plan, Florida DOT developed a multistep process for project selection and prioritization. The process aimed to be logical and practicable, to gain stakeholder support.

The initially identified projects fit the freight project definition and were located on the freight network. Florida DOT districts and MPOs already had included many of the projects in their plans, but a robust process of stakeholder engagement allowed private-sector entities to identify and nominate additional freight projects.

Unlike many freight plans, the Florida DOT plan involved the freight stakeholders—carriers, shippers, and others representing manufacturing, agriculture, mining, and distribution—in the development of the 26 project selection criteria reflecting the freight plan strategy, goals, and objectives (Table 1, right). This approach ensured the linkage of freight projects with freight mobility needs and established the integrity of the plan.

TABLE 1 Florida DOT Freight Project Prioritization Criteria

Criterion	Average Importance Rating
Addresses a transportation challenge for an industry targeted by Enterprise Florida	4.0
Improves access to or from a current or developing freight hub	4.5
Improves the export capability and capacity of an intermodal logistics center (ILC)	3.9
Supports or strengthens the unique niche of a seaport, airport, spaceport, rail freight terminal, or ILC	4.1
Responds to an identified market need	4.2
On a designated Florida Freight Network facility	4.1
Eliminates a freight bottleneck	4.4
Provides a dedicated freight facility or freight shuttle that restores capacity for freight movement	3.6
Uses information technology to improve system operations	3.7
Improves truck parking	3.4
Improves safety and security at rest stops, layover areas, or other facilities	3.3
Stimulates use of marine highways or short sea shipping	3.4
Reduces empty backhaul movements to cut shipping costs	3.8
Improves access to compressed natural gas, liquefied natural gas, or other alternative fuels	3.4
Minimizes costs throughout the supply chain, to support manufacturing	3.9
Privately funded	4.1
In a local freight plan	4.1
Consistent with a statewide modal plan	3.9
Supports an emerging freight facility	3.7
Benefits taxpayers	4.2
Provides significant intermodal benefits for multiple freight modes	4.1
Total cost	4.2
Funding status	4.1
Timing and readiness	4.2
Included in transportation improvement program or statewide transportation improvement program	3.9
Dependency on other projects	4.1

The stakeholders then prioritized the selection criteria, which yielded a weighting system. All projects were filtered through the criteria, scored with the assigned points, and grouped by priority.

The project selection and prioritization methodology developed for Florida was objective—all projects were evaluated equitably and alike. The unbiased

PHOTO: INES HEGEDUS GARCIA, FLICKR

Cranes at the Port of Miami, Florida; the state's Freight Mobility and Trade Plan developed a multistep process for project selection and prioritization, incorporating 26 criteria for project selection.

approach provided Florida DOT with a transparent, flexible, and easily administered process.

The Florida DOT process included the following:

- Development of criteria for prioritizing freight projects,
- Rating projects according to the criteria,
- Weighting each criterion by its importance,
- Compiling project scores and grouping projects by priority scores, and
- Evaluating the return on investment.

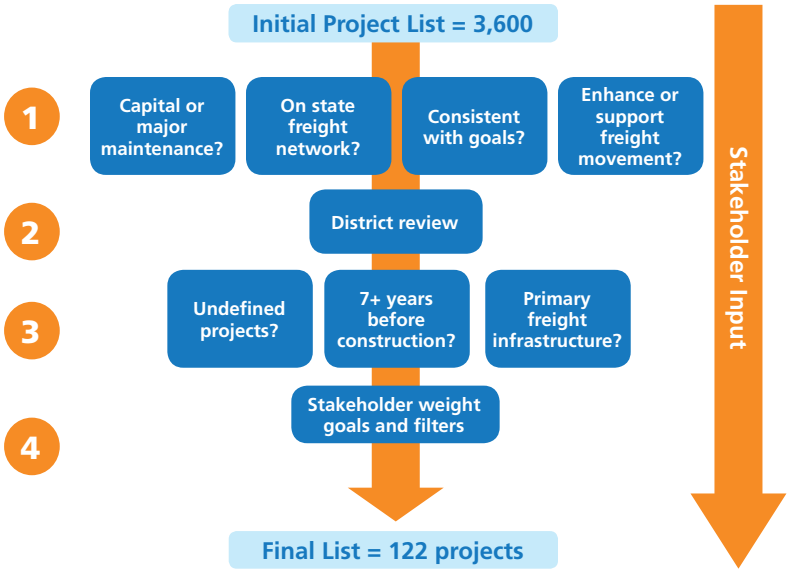


FIGURE 2 Steps in selection of Missouri freight projects.

Missouri: Decision Making

Missouri required a methodology for selecting and prioritizing freight projects objectively and equitably, one that would be easily understood by stakeholders and other interested parties. The process would be structured and transparent. The Missouri State Freight Plan (MSFP) called this methodology the decision-making process, underscoring the goal of determining the best strategic investment choices for freight projects and putting the shovels to the ground for quick start-ups.

The decision-making process began with the goals and objectives in the MSFP, developed to align with the goals of the state's long-range transportation plan and with MAP-21 guidance. The MSFP focused on four key areas: maintenance, safety, economy, and connectivity and mobility. The prioritization process honed in on the freight projects that provided the most benefits in these areas (Figure 2, lower left).

Missouri DOT identified and designated the Missouri Freight Network, including transportation assets critical to the movement of goods and commodities in the state. The volumes of freight by tonnage, value, and commercial vehicle traffic counts determined the multimodal network.

The decision-making process included four tiers. First, each project was evaluated in terms of the MSFP goals and its location on the designated freight network. The Missouri DOT districts led the Tier 2 review, which ensured that the project met regional needs. Projects were added or deleted based on regional freight needs.

The third tier eliminated projects that were speculative—that is, projects that were too vague, that could not be advanced within seven years, or that served nonfreight needs. Tier 3 separated out the major statewide planning projects and redefined others as regional projects.

The next phase developed the filters for prioritization and the factors for scoring. Each freight project was evaluated and prioritized according to the 29 filters and factors (Table 2, page 25). The process applied similar filters to freight rail, waterborne, and aviation-centric projects. All filters were not equal—for scoring, the filters were weighted to emphasize criteria deemed more important by Missouri DOT and freight stakeholders.

The final step classified each project within a priority group. The expected impact of the project determined its priority.

Missouri DOT has decided to repeat this process annually. As projects are initiated and more information becomes available, projects in the lower priority groups are likely to rise to higher levels.

PHOTO: MELINDA STUART, FLICKR

A tugboat traverses the Mississippi River near St. Louis, Missouri. The Missouri State Freight Plan included four tiers to determine the transportation assets critical to the movement of goods and commodities.

Pennsylvania: Developing a Tool

Pennsylvania DOT designed a prioritization tool to guide the state's investment decisions and to provide a quantitative means of evaluating projects across modes. The agency worked with planning partners to develop the initial prioritization network, the multimodal project types, the criteria, and the scoring.

Pennsylvania DOT tapped stakeholders in its Long-Range Transportation Plan and Comprehensive Freight Movement Plan, partners from MPO and regional planning organization (RPO) projects, and members of the Pennsylvania On-Track Advisory and Management Committees, the technical and senior-level steering committees for the agency. The transparent stakeholder involvement refined and improved the process.

TABLE 2 Missouri DOT Freight Project Prioritization Filters: Highway Mode

Freight Plan Goal	*Recommended Measures*
Major maintenance	• Maintains current network
Safety	• Reduces the number of substandard bridges • Improves locations with high numbers of truck crashes
Economic development	• Improves connection to a top freight generator • High scores for economic linkages
Connectivity and mobility	• Improves vertical clearance or weight restrictions on bridges • Addresses a freight bottleneck • Improves a multimodal connector • Improves capacity

Projects were prioritized based on two scores—technical and economic impact. The tool relied on a geographic information system (GIS) platform that drew on several databases. Drop-down tables within the Project Profile Creator allowed a user to select specific guidelines and criteria for various project types.

Technical scores derived from an analysis of each project based on 63 evaluation criteria developed for nine multimodal project types; plans call for more types to be added. A model developed exclusively for this process generated an economic impact score.

The prioritization applied to a range of project types, including highways, freight and passenger rail, ports and waterways, and interregional commuter bus service. Formulas embedded in the tool generated quantitative data—including average annual daily traffic, highway capacity, truck volumes, network delay, vehicle miles of travel, population and employment density, and connections to public transportation and intermodal facilities.

The tool also incorporated qualitative data, such as interchange design elements and sustainable land use protections (Figure 3, page 26). The economic

PHOTO: STATEOFPLACE, FLICKR

A southbound truck leaves a tollbooth on the Pennsylvania Turnpike.

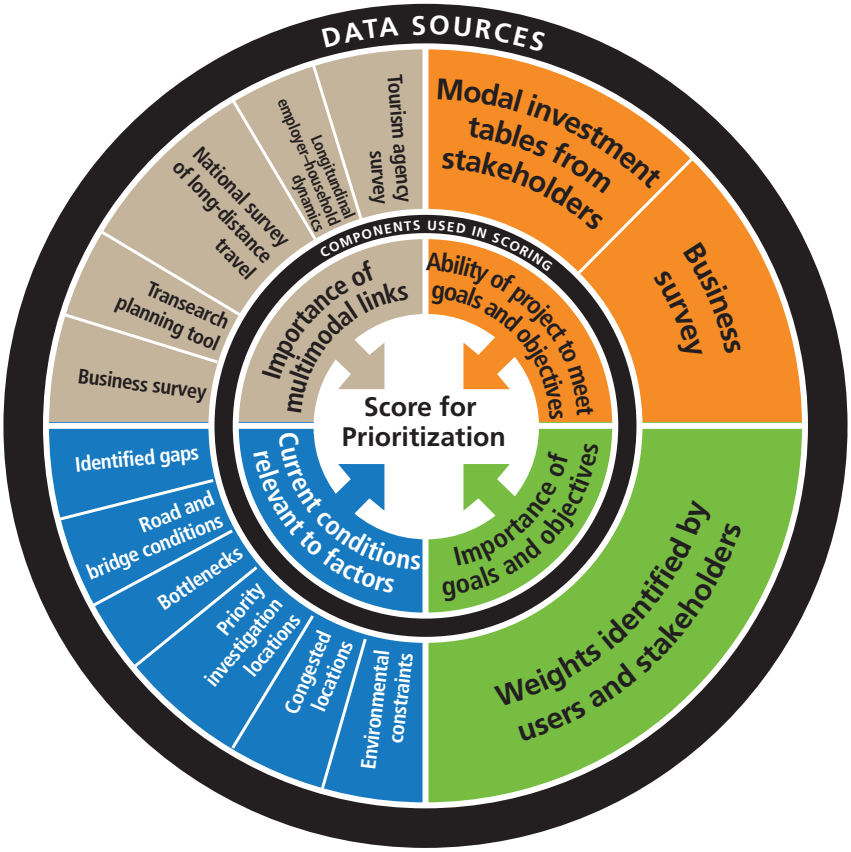


FIGURE 3 Data sources and scoring components of Pennsylvania's freight tool.

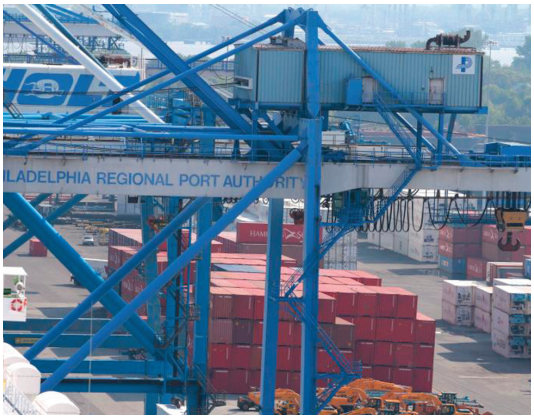


PHOTO: RAYMONDCLARKEIMAGES, FLICKR

Containers at the Port of Philadelphia, Pennsylvania. The state DOT's freight plan applied to a range of projects, including highways, freight and passenger rail, and ports and waterways.

impact model used algorithms and regression analysis to drive the outputs, merging with the input–output economic impact model IMPLAN,[1] which allows users to define industries, economic relationships, and projects to be analyzed.

Pennsylvania DOT's prioritization process can support transportation decision making for planning at the state and regional levels. The process and tool can generate reports for each project and for groups of projects, including statewide prioritization rankings for each project, project prioritization rankings for each district and for each MPO and RPO, and a scatterplot diagram for all projects, showing total project cost compared with the total project score, the technical score, and the economic score.

[1] Impact analysis for planning.

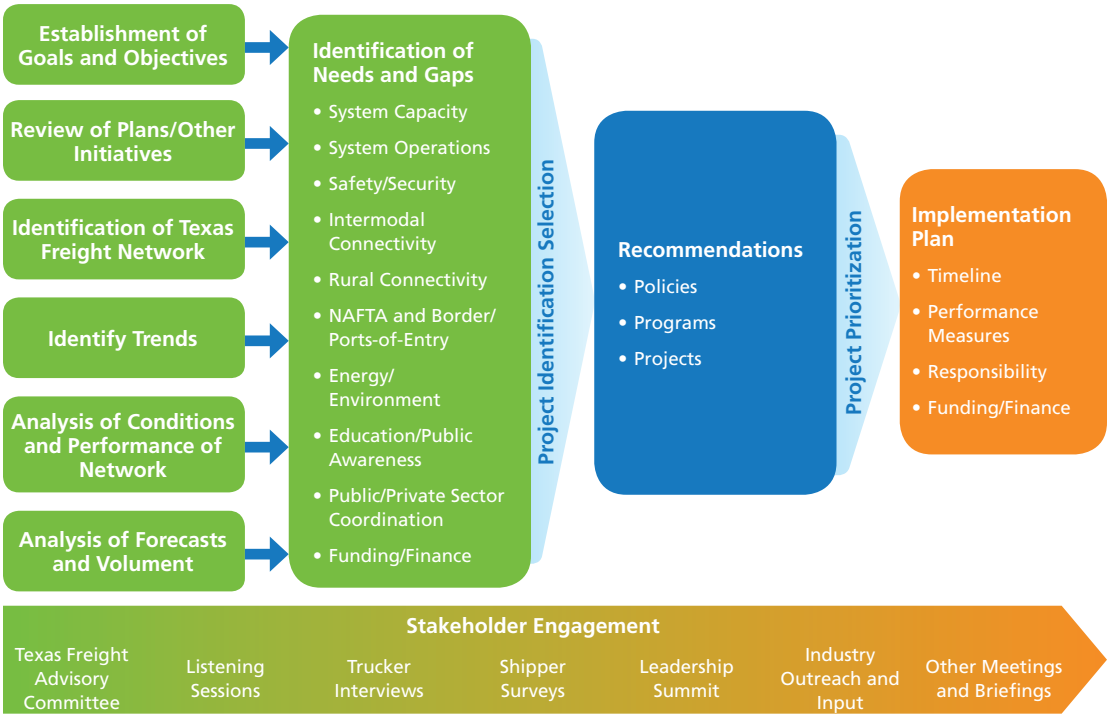


FIGURE 4 Development of Texas implementation plan.

Texas: Business Case

Texas DOT is making a transition to a performance-based management system that includes metrics to identify issues and needs. Once developed, the system will play a key role in project selection and prioritization (Figure 4, page 26).

The Texas Freight Mobility Plan (TFMP) sets forth the business case, predicated on trends, needs, and issues, for strategic investments in efficient and safe multimodal transportation to improve freight mobility. The Texas Freight Network, which includes highways, rail, the Gulf Intracoastal Waterway, seaports, cargo airports, and pipelines—provides the framework for project recommendations (Figure 5, right).

Nevertheless, highway projects on the Texas Freight Network proceeded separately from projects for the other freight modes. Project selection for the rail, waterways, air, and pipeline modes followed stakeholder input and separate Texas DOT plans.

Initially the Texas DOT programming process ranked all freight projects by their timing. Many projects were already in the fiscally constrained 10-year Unified Transportation Plan (UTP), and others were labeled "Development Authority"—that is, over and above the UTP's fiscally constrained funding limit.

Texas DOT then categorized all projects as high, medium, or low priority, commensurate with associated needs, and identified all projects by freight mode, including the category of Border and Ports of Entry. Texas DOT intends to conduct this process annually. As in Missouri, once projects are initiated and more information becomes available, projects on hold are likely to gain priority.

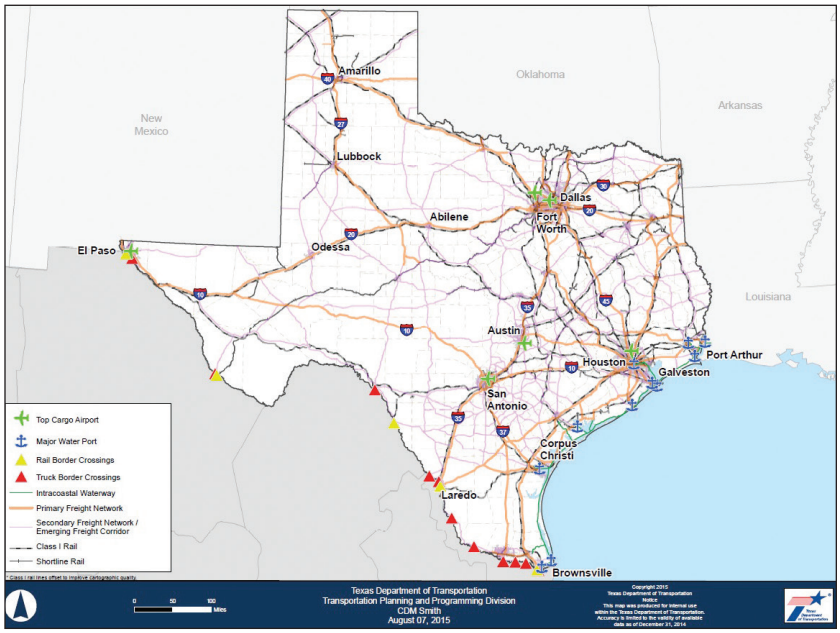


FIGURE 5 Texas Freight Network.

The Texas Freight Network includes highways, rail, the Gulf Intracoastal Waterway (*below*), seaports, cargo airports, and pipelines.

Stakeholder Engagement

In all four case studies, freight stakeholders played a critical role in identifying, developing, and executing the selection and prioritization of projects within the state freight plan. This involvement ensures that the stakeholders buy in to the implementation of the plan.

The common step-by-step approach was as follows:

- Develop freight goals;
- Define the freight network, including all modes;
- Identify freight projects;
- Evaluate projects against goals, the network, and freight-focused needs;
- Evaluate projects against selection filters or criteria;
- Score the projects; and
- Categorize the projects into priority groups.

Each of the state DOTs sought to maximize stakeholder engagement in the freight planning process, to include stakeholder input into freight project selection and development of a methodology to set priorities. As users of the freight system, the stakeholders illuminated issues and needs for freight projects.

Stakeholder involvement early and often served to inform the process, to facilitate a partnership between the provider and users, and to impart integrity to the outcome. The results produced state freight investment plans that enable economic development and provide the best return on investment to citizens and taxpayers.

PHOTO: U.S. ARMY CORPS OF ENGINEERS, FLICKR

NCHRP REPORT 809

Environmental Performance Measures for State Departments of Transportation

ANNA BATISTA, JOE CROSSETT, JEFF ANG-OLSON, AND JEFF FRANTZ

Batista is Senior Consultant, High Street Consulting Group, LLC, Chevy Chase, Maryland. Crossett is Principal, High Street Consulting Group, LLC, Pittsburgh, Pennsylvania. Ang-Olson is Vice-President, ICF, Sacramento, California. Frantz is Vice President, CH2M, Chicago, Illinois.

Building and operating transportation systems has indisputable impacts on the air, the water, and the ecosystems that make up the natural environment. A state department of transportation (DOT) looking to address environmental concerns effectively while fulfilling its core mission therefore must include environmentally focused performance measures in its transportation planning.

Performance management has emerged as a mainstream business practice among state DOTs. Although agencies are increasingly harmonized in their approaches to performance measurement in infrastructure preservation, safety, and congestion management, the strategies for measuring environmental performance vary, and guidance on the use and usefulness of measures had been scant.

National Cooperative Highway Research Program (NCHRP) Report 809, *Environmental Performance Measures for State Departments of Transportation* (*1*), provides a first step toward guidance, by establishing and demonstrating the practicality of a suite of core environmental measures. The findings provide a framework for a nationwide conversation among transportation practitioners and their stakeholders about the kind of environmental performance measures that could lead to advances in environmental stewardship.

Performance Measure Principles

The environment is a multifaceted subject, and environmental issues are often partly or completely outside of a state DOT's control; as a result, outcomes

PHOTO: MISSOURI DEPARTMENT OF TRANSPORTATION, FLICKR

Construction progresses on the Daniel Boone Bridge over the Missouri River between St. Louis and St. Charles counties in Missouri. Bridge construction raises a host of environmental concerns.

may not be greatly influenced by a state DOT's actions. A state DOT therefore should ensure that environmental measures are used with the proper goal in mind and in the most relevant mission area.

Function of Measures

Performance measures mostly serve one or more of three broad functions in a state DOT:

- Building external accountability and enhancing the agency's credibility,
- Supporting analytic tools and internal decision making, and
- Serving as management tools that indicate a focus for staff efforts.

Applying a measure in accordance with the function it serves will increase the measure's usefulness to the organization and ensure success in implementation.

Applicability to Core Mission

A state DOT's mission begins with strategic planning and extends to long-range plan development, to short-range programming, project planning, design, construction, and finally system operations and maintenance. Environmental measures have varying degrees of relevance to each of these elements, and this should be considered before putting a measure into effect.

Target Setting

Target setting is generally crucial to performance management but under some circumstances may not be practical or desirable—for example, a focus on numbers can draw staff attention from other issues or can cause stakeholder confusion. Other pitfalls in target setting include the following:

- Measures that track issues outside a state DOT's control—although these may indicate a commitment to improvement, the agency has limited power to achieve the formal target; and
- Newly created measures—because these lack historical precedent, the targets are subject to revision when greater clarity emerges about performance trends.

Focus Areas

The environment may be thought of as a single strategic priority but is a complex and multifaceted topic. Performance therefore cannot be captured easily by a single metric. For this reason, the proposed measures span five major focus areas:

PHOTO: OREGON DEPARTMENT OF TRANSPORTATION, FLICKR

An elk traverses a highway undercrossing in Oregon.

- Air quality,
- Energy and climate,
- Materials use,
- Stormwater, and
- Wildlife and ecosystems.

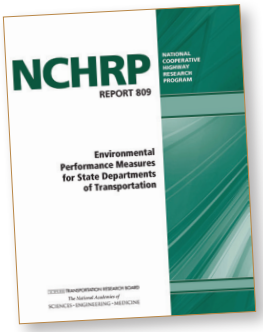
These five focus areas are susceptible to adverse impacts from transportation. Together, the five areas comprise a comprehensive and broadly shared set of environment-related interests in most state DOTs, providing a credible foundation for creating strong measures.

Selecting Measures

The project team selected one or two performance measures for each focus area (see Table 1, below). The measures come closest to meeting desired

TABLE 1 Suggested Environmental Performance Measures

Focus Area	*Measure*	*Description*
Air Quality	Motor vehicle emissions	Change in statewide motor vehicle emissions for oxides of nitrogen (NO_x), volatile organic compounds, and fine particulate matter ($PM_{2.5}$)
Energy and Climate	Gasoline consumption	Statewide on-road gasoline consumption per capita
	State DOT alternative fuel use	State DOT fleet use of alternative fuel as percent of total fleet fuel use (by volume)
Materials Recycling	Reclaimed asphalt pavement (RAP) usage	Annual percent by mass of all roadway asphalt pavement materials composed of RAP used by state DOT
Stormwater	Stormwater treatment	Percent of state DOT–owned impervious surface for which stormwater treatment is provided
Wildlife and Ecosystems	Self-administered Ecosystems Self-Assessment Tool (ESAT)	41 questions that evaluate performance across all aspects of state DOT programs relevant to wildlife and ecosystems



NCHRP Report 809, *Environmental Performance Measures for State Departments of Transportation*, is available from the TRB online bookstore, https://www.mytrb.org/Store/Product.aspx?ID=7859; to view the book online, go to www.trb.org/Publications/Blurbs/173012.aspx.

criteria in the context of today's environmental and technological know-how and political constraints. None of the measures, however, is perfect, but each provides state DOTs with a practical and improvable gauge.

The project compiled nearly 200 environmentally focused performance measures currently in use or identified in the transportation literature. To choose the most promising measures from the list, the team developed screening criteria—the ideal environmental measures should satisfy all or most of the following conditions:

- Address an issue of significance,
- Link directly to an environmental outcome,
- Be within a state DOT's power and influence to achieve,
- Yield results valuable to decision makers, and
- Prove meaningful and understandable to the public.

These criteria winnowed the list down to the most promising measures for proof-of-concept validation. No environmental performance measure fully met all of the criteria; the selected measures, however, were found to come as close as possible to the ideals.

Individual Measures

Air Quality: Vehicle Emissions

Change in statewide motor vehicle emissions can measure the direct link between vehicle emissions and air quality outcomes. Although state DOTs do not have direct control over microlevel factors that drive most of the year-to-year changes in emissions—such as driving habits or vehicle makeup—the agencies play an important role in the longer-term outcomes.

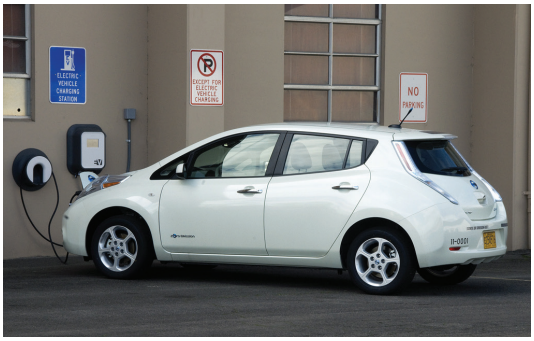


PHOTO: OREGON DEPARTMENT OF TRANSPORTATION, FLICKR

An Oregon DOT fleet car recharges. Alternative fuel use by a state DOT's fleet demonstrates commitment to the reduction of harmful emissions.

For example, state DOTs can affect motor vehicle emissions by planning and building multimodal transportation systems that offer low-emission travel choices and that reduce the recurring and nonrecurring congestion producing higher emissions. The measure therefore strikes a good balance between a state DOT's level of control and the desired outcome.

Energy and Climate: Alternative Fuels and Gasoline

The two measures in the energy and climate focus area address the balance between state DOT control and impact on environmental outcomes. Alternative fuel use by a state DOT's fleet measures the agency's own reduction in fossil fuel use.

Because the state DOT directly controls this metric, the data tracking is relatively easy to implement. Admittedly, a DOT fleet consumes only a small fraction of all fuel and does not have a significant impact on total energy use or on climate effects; the second measure, however, addresses this.

PHOTO: WENDY HOUSE, FLICKR

Vehicles undergo emissions tests in Washington State. State agencies play an important role in the longer-term outcomes of motor vehicle emission reduction.

Highway gasoline consumption per capita is a clear measure of energy use and has climate effects. The measure also relates to such public-sector goals as reducing emissions, improving fleet fuel efficiency, limiting dependency on petroleum fuels, and managing growth in vehicle miles traveled. Each state already tracks gasoline consumption for other purposes—the data gathering is easy, and the metric is understandable to the general public.

Materials Recycling: RAP

Reclaimed asphalt pavement (RAP) reuses materials containing asphalt and aggregates removed from old roads for reconstruction or resurfacing—essentially road recycling. Using RAP instead of new asphalt conserves energy, reduces landfill waste, conserves natural resources, and reduces agency and contractor costs.

Asphalt and aggregate represent two of the most frequently used materials in a state DOT's operation, and RAP has become the most common recycling practice among state DOTs. This measure therefore has an impact on the environment and is familiar to state DOTs. Accounting for RAP usage is straightforward and may require input from the state DOT's road contractors.

Stormwater: Impervious Surfaces

Stormwater runoff is a universally significant issue for any local government or agency responsible for large areas of impervious surfaces, such as roads, sidewalks, and parking lots. As the owners of much of each state's public road system, state DOTs are important players in stormwater treatment.

The measure relies on structural best management practices (BMPs), which are designed or engineered physical installations near roads to manage the flow of stormwater runoff, often by filtering or otherwise treating the runoff to improve water quality.

Using BMPs for the measure has advantages. First, BMPs are in common use by state DOTs, and the extent of implementation can be documented. BMPs contribute directly to environmental improvement by actively managing water quantity or quality; moreover, their use is completely within a state DOT's control.

Wildlife and Ecosystems: Self-Assessment Tool

A state DOT's mission includes ongoing construction on a statewide scale, which can greatly affect natural ecosystems and the wildlife that depends on them. Natural habitats vary widely from state to state, and each state's resource agencies and DOT may emphasize different natural resource issues. Finding a universally relevant measure for ecosystems therefore is a challenge.

The research team finally settled on the Ecosystems Self-Assessment Tool (ESAT), composed of 41 questions that evaluate performance across all aspects of state DOT programs related to wildlife and ecosystems. The ESAT takes into account and gives credit for almost any action that a transportation organization uses to reduce its impact on wildlife and ecosystems. This allows consistency in measuring outcomes across states with different wildlife and ecosystems.

Photo: North Carolina Department of Transportation, Flickr

A milling machine removes asphalt from Interstate 85 in North Carolina; recycled asphalt pavement conserves energy while reducing landfill waste and contractor costs.

Testing the Measures

Each measure addresses an environmental issue of significance, focuses on desired outcomes within a state DOT's control, and yields information to decision makers and clarity to the public. Without good data, however, none of these measures is usable.

Photo: Oregon Department of Transportation, Flickr

Oregon's animal undercrossings accommodate a variety of wildlife, including coyotes.

Proof-of-concept testing therefore applied data from 27 state DOTs to demonstrate the validity of the proposed measures in terms of three quantitative criteria:

- States can apply the measure consistently,
- The necessary data are available or can be generated easily, and
- The data quality is credible and defensible.

Table 2 (below) shows the states that participated in the testing for each measure. The results reflect the variety of environmental performance measurement among state DOTs (see Table 3, page 33)—no state could provide data for every measure. Nonetheless, the proof-of-concept testing demonstrated the viability of the measures within a subset of states.

Findings

Each measure fell into one of three categories: suitable for use in the near term, suitable for use in the long term, or not suitable for use.

- *Suitable for use in the near term*—The proof-of-concept testing generally validated the measures of on-road emissions, gasoline consumption, alternative fuel use by the agency, and RAP usage for adoption in the near term. The availability and com-

TABLE 2 Summary of Participating Pilot States

	Comprehensive Statewide Data Obtained				*Experimental Data Obtained*	
		Energy–Climate Change:				
State	*Air: Statewide Vehicle Emissions*	*Gasoline Consumption per Capita*	*State DOT Fleet Alternative Fuels Use*	*Recycling: RAP as Percentage of Total Pavement*	*Stormwater: Percentage of Roads Treated*	*Wildlife and Ecosystems: ESAT*
California	x	x	x			
Colorado	x	x		x		
Delaware	x	x		x	x	
Florida	x	x		x		
Georgia		x				x
Illinois	x	x		x		x
Iowa		x	x			
Maine		x	x			
Maryland	x	x	x		x	x
Minnesota		x	x		x	x
Missouri	x	x	x	x		
Nebraska		x	x			
New Jersey	x	x		x		
New Mexico		x	x			
North Carolina	x	x	x	x	x	
North Dakota	x	x		x		
Ohio		x			x	x
Oregon		x				x
Pennsylvania	x	x	x	x		
South Carolina		x	x			
South Dakota	x	x		x		
Texas		x				x
Utah		x		x		
Vermont	x	x	x			
Virginia	x	x				
Washington	x	x	x			
Wyoming	x	x	x			
Total	**16**	**27**	**14**	**11**	**5**	**7**

prehensiveness of the data and the viability of the methods to calculate the measures presented few barriers to implementation by state DOTs.

◆ *Suitable for use in the long term*—The stormwater and final wildlife and ecosystems core measures are clearly experimental, and only a handful of state DOTs had capabilities in these two areas—sometimes only nascently or in pilot testing. Although the stormwater treatment and ESAT measures may not be ready for immediate implementation, the testing suggested strong promise, and continued efforts to expand the measures are encouraged, with a goal of phased adoption.

◆ *Not suitable for use*—The initially proposed wildlife and ecosystem measure, "Share of mitigation obligations with on-time regulatory approval," proved unsuccessful at two of the three pilot DOTs. Further research showed that the extensive use of mitigation banking to fulfill obligations was a widespread practice at many state DOTs, making this measure less effective.

Next Steps

Performance measurement is a continual journey. None of the 27 states involved in the proof-of-concept testing could easily provide data for all measures. Clearly, all 50 states are not ready to implement a complete set of environmental measures immediately. But the testing suggests that the measures are within reach and point to several logical next steps:

◆ **Conduct an environmental performance measures workshop for state DOTs.** A workshop could convene state DOT representatives to discuss environmental performance research findings and to encourage uniform adoption of the measures by the states.

◆ **Collect full-scale or partial data.** All or some states could be encouraged to collect and report data for all or some of the measures. This could be a goal of the workshop and may involve a regular meeting of states to share lessons learned as the data are collected.

PHOTO: VIRGINIA DEPARTMENT OF TRANSPORTATION, FLICKR

More than 8,000 pollinator-friendly plants are planted at a highway rest area in Dale City, Virginia, part of the Virginia DOT's Pollinator Habitat Program to protect Monarch butterflies.

◆ **Explore trends and map target-setting opportunities.** Examining trends and concerns as the data are collected will assist in developing robust approaches to target setting.

◆ **Launch a website for reporting performance.** The NCHRP Report 809 findings provide a foundation for a website that could allow centralized tracking and reporting of state DOT performance on each of the core environmental performance measures.

◆ **Enhance the performance measure methodologies.** The essential ideas of the performance measures can develop further, through improvements in the methodologies or by making the calculations more precise.

The search for ideal environmental performance measures often changes direction with shifts in industry practices, technology, or politics. Nonetheless, the measures proposed in NCHRP Report 809 present a practical map for the path ahead in developing more robust environmental performance measures for state DOTs

Reference

1. Crossett, J., J. Ang-Olson, and J. Frantz. *NCHRP Report 809: Environmental Performance Measures for State Departments of Transportation*. Transportation Research Board, Washington, D.C., 2015. www.trb.org/Publications/Blurbs/173012.aspx.

TABLE 3 Summary of Results from Proof-of-Concept Testing

Measure	*Supports Consistent Application from State to State?*	*Data Are Available or Easy to Generate?*	*Data Quality Is Credible and Defensible?*	*State DOT Readiness for Implementation*
Vehicle emissions	Fully	Somewhat	Mostly	Ready for use
Alternative fuel use	Mostly	Mostly	Fully	Ready for use
Gasoline consumption	Fully	Fully	Fully	Ready for use
RAP usage	Fully	Somewhat	Mostly	Ready for use
Stormwater treatment	Somewhat	Lacking	Lacking	Suitable for future use
ESAT	Somewhat	Fully	Somewhat	Suitable for future use

NCHRP SYNTHESIS 460

Sharing Operations Data Among Agencies

MICHAEL L. PACK

The author is Director, Center for Advanced Transportation Technology Laboratory, University of Maryland, College Park.

Parents struggle to teach toddlers about sharing; toddlers are threatened by the idea of sharing, and do not understand that sharing has merits. Parents know that sharing is important for relationships and social growth. Every child-rearing book covers the topic of sharing, and research by child psychologists backs up the principles. In some ways, transportation, law enforcement, and other public safety agencies are working their way through the difficult toddler stage.

In the transportation operations community, the sharing of data between agencies may invite comparisons that do not reflect well on agencies that seem to be underperforming. In addition, some may believe that modifying practices to collect data in a format compatible with the format used by other agencies is not a good application of constrained funding. National Cooperative Highway Research Program (NCHRP) Synthesis 460, *Sharing Operations Data Among Agencies*, outlines the many ways that sharing data among agencies can have significant benefits.

PHOTO: MINNESOTA DEPARTMENT OF TRANSPORTATION

Minnesota DOT's Regional Transportation Management Center in Roseville coordinates data sharing between State Patrol, the DOT's Maintenance, and the DOT's Freeway Operations.

Advancing Capabilities

Maximizing the benefits of regional operations and integrated corridor management programs entails the sharing and fusing of data from disparate agencies and systems. For example, signals in one jurisdiction may need to sync with those of a neighboring jurisdiction. Transit agencies must be able to adapt schedules for special events, emergencies, or other disruptions of normal travel patterns. Police, fire, and rescue agencies need to coordinate with operations and maintenance units of the state and local departments of transportation (DOTs) to clear incidents quickly while ensuring the safety of the responders and of the travelers in the queue.

These multiagency integrated operations are not achievable policies for open and accessible data sharing, and these policies will not change unless sound research affirms the benefits of sharing operations data. Synthesis 460 is one of the first steps.

One study referenced in the synthesis reveals how a single large-scale incident managed with data shared by multiple agencies can yield hundreds of thousands of dollars in benefits. Hundreds of similar incidents occur every year, potentially yielding tens of millions of dollars in benefits gained through open data sharing. Many of the agencies consulted in assembling the report anecdotally identified significant internal cost savings after receiving data from other agencies.

Benefits of Sharing

NCHRP Synthesis 460 documents how the coordi-

IMAGE FROM NCHRP SYNTHESIS 460

The Regional Integrated Transportation Information System (RITIS) collects and fuses transportation data from agencies in the Washington, D.C., metropolitan region; a RITIS virtual weigh station (*below*) uses sensors to visualize axle spacing, axle weights, and other measurements to target enforcement activities.

nation and sharing of operations data can accomplish the following:

- ◆ Enable the coordination of signal timing plans between jurisdictions;
- ◆ Improve coordination of commodity flows for shippers;
- ◆ Enhance interagency transit and mode coordination;
- ◆ Free up agency staff to work on other tasks;
- ◆ Help agencies coordinate work zones and lane closures;
- ◆ Improve information flow and coordination between all jurisdictions and agencies involved in an incident;
- ◆ Enhance the understanding of joint priorities and restrictions by all agencies responsible for addressing an incident;
- ◆ Provide a single set of objectives for all who are working to resolve an incident, enabling a collective approach to develop and achieve traffic incident management strategies; and
- ◆ Optimize the combined efforts of all agencies as they perform their assignments to mitigate the impacts of incidents, leading to significant benefits in terms of
  - – Safety,
  - – Congestion reduction,
  - – The environment, and
  - – Cost savings to the agencies and the public.

In addition, the synthesis documents how the provision of real-time feeds of data to external entities can reduce workloads and improve the coordination of incident response.

Addressing Hindrances

Despite the well-documented successes of this approach, many challenges still impede the willingness and ability of some agencies to share and to cooperate fully. At a basic level, these challenges parallel those of toddlers: ownership issues, fear, and a lack of understanding the benefits.

The most significant hindrances for agencies include the fear of being judged, legal concerns, potential security threats, funding, and technical capacity—especially in relation to more detailed operations data, such as responder notifications, arrival times, computer-aided dispatch from law enforcement, and personally identifiable information. The synthesis findings, however, show that all of these problems can be overcome and that improved understanding readily reveals that the benefits outweigh the fears.

Most transportation conferences nowadays feature a session on integrated corridor management (ICM) or regional operations. These initiatives aim to increase the cooperation between transportation agencies—including state and local DOTs and bus and rail providers—and between disciplines—such as freeway operations, signal operations, transit operations, parking management, and traveler information providers. The goal is to increase drastically the capabilities for mobility, safety, and event response by all involved.

When crossing state borders, these initiatives grow in size and complexity. Despite the recognition that ICM and regional operations have merit, agencies are still apprehensive about doing what is necessary to make ICM and regional operations effective—namely, sharing data, sharing control, and making collaborative decisions.

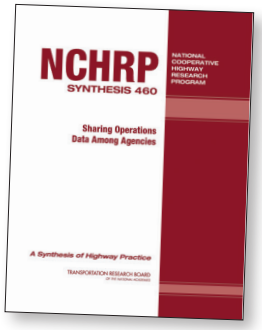
PHOTO: KEN LUND, FLICKR

Traffic crosses the George Washington Bridge connecting New York with New Jersey and serving as a key link on the Interstate 95 corridor.

Positive Changes

The child-rearing books advise: Don't force it. Work on self-esteem. Explain the concept of "other people's things." Lead by example. Provide opportunities. Work on coplay instead of parallel play. The Synthesis 460 findings show that similar concepts work in transportation operations and offer a practical resource for any agency struggling to understand—or to convince its leadership about—the many benefits of sharing their data with other agencies.

Synthesis 460 offers examples of law enforcement, fire and rescue, and transportation operations agencies that have experienced positive change within their organizations as a result of sharing operations data.



NCHRP Synthesis 460, *Sharing Operations Data Among Agencies*, is available from the TRB online bookstore, https://www.mytrb.org/Store/Product.aspx?ID=7204; to view the book online, go to www.trb.org/Publications/Blurbs/170868.aspx.

Reference

1. Pack, M. L., and N. Ivanov. *NCHRP Synthesis 460: Sharing Operations Data Among Agencies*. Transportation Research Board of the National Academies, Washington, D.C., 2014.

Debra A. Nelson

New York State Department of Transportation

Debra A. Nelson began her career as a field research technician on the remote tundra of Alaska. She says that she views life as one big adventure and has found "you never know where it will lead you." For instance, in the last month of her first field season, she forged on alone into the wilderness after the principal investigator had to return for family reasons. Nelson's work has evolved to include national and international research on the interrelationship of ecology, sustainability, and resilience in transportation.

"These opportunities have allowed me to become a leader in sharing the most cutting-edge and progressive material on the ever-evolving role of environment in transportation," Nelson comments. After receiving a bachelor's degree in forestry from the University of Massachusetts–Amherst in 1984, she joined the National Park Service to study the effects of all-terrain vehicle use on tundra vegetation and soils at a remote field station in Wrangell–Saint Elias National Park and Preserve in Alaska. Nelson returned to the lower 48 states in 1987 and worked as an ecologist and environmental scientist at private firms before joining the New York State Department of Transportation (DOT) in 1992.

"In the environmental stewardship movement, a sequence of incremental victories eventually created a sea change."

At New York State DOT, Nelson has led efforts to advance the agency's environmental ethic and sustainability mission. In 2001, she quips she "traded in her boots for suits" to head the Water Ecology Section of the agency's Environmental Analysis Bureau, guiding national, regional, and state environmental stewardship efforts and policy development in transportation activities. Since 2009, Nelson has assisted executive management on a range of priority focus areas, including asset management, emergency response, sustainability, and resilience. Her experience as New York State DOT's deputy incident commander for Hurricane Irene and Tropical Storm Lee and her involvement in emergency response for Hurricane Sandy reinforced the importance of resilience and sustainability in transportation. Nelson leads the agency's Solar Highway Initiative and the Federal Highway Administration Climate Change Resilience Pilot Project, among other efforts. She continues to pursue her love of learning—she recently received a master's degree in regional planning from the University at Albany with concentrations in transportation planning and community planning. She also earned a graduate certificate in urban policy in May 2015.

"In three decades of working in this field, I have seen environmental issues in transportation shift from being a nuisance to be routinely incorporated into everything we do," Nelson observes. "It was incredibly rewarding to be part of state and national efforts in the late 1990s that facilitated the impressive shift in attitude from regulatory obligation to environmental stewardship." The culmination of these efforts, she adds, is the philosophy that transportation should support a sustainable society—this has become mainstream.

"Change takes time, which is why it's important to celebrate the little victories," she maintains. "In the environmental stewardship movement, a sequence of incremental victories eventually created a sea change. It takes patience, hard work, good information, and dedicated champions." Nelson quotes the anthropologist Margaret Mead: "Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has."

Nelson helped form the TRB Task Force on Ecology and Transportation in 2003, and continued involvement after it became a standing committee in 2007. She served on several National Cooperative Highway Research Program and second Strategic Highway Research Program (SHRP 2) panels and task groups, covering topics such as environment protection pilots, temporary bridging of wetlands, resilience research, and adaptation for extreme weather events. Nelson chaired a SHRP 2 expert task group on the integration of national-level geospatial ecological tools and data, and she was appointed to the SHRP 2 Technical Coordinating Committee on Capacity Research. She is currently a member of the standing committees on Environmental Analysis in Transportation and on Transportation and Sustainability and serves as New York's TRB state representative for research.

Nelson has been a member of the Steering Committee of the International Conference on Ecology and Transportation since 2001, serving as chair for three programs—in Arizona, 2013; North Carolina, 2015; and Utah, 2017. She also served as a technical panel member for a National Highway Institute course on conflict management skills for environmental issues.

"In the end, it's all about people," Nelson comments. "Teamwork, innovation, creativity, synergy, collaboration, and fun—this is what drives me to make a difference. I never go it alone; I get the most from my experiences when I can share the excitement and energy. I love to mentor and encourage future leaders and to provide them with opportunities for professional and personal growth."

Judith B. Corley-Lay

North Carolina Department of Transportation

For more than 25 years, Judith B. Corley-Lay taught, conducted, and facilitated hands-on research in pavement analysis and design, pavement management, soil mechanics, and foundation engineering at North Carolina Department of Transportation (DOT), from which she retired last fall. "I was lucky to be able to participate in research at several levels," Corley-Lay comments. "I did in-house studies on performance of various treatments, including a comparison of plant-mixed and road-mixed cement-treated aggregate base course, a study of base type on jointed concrete pavements in North Carolina, and performance of ultrathin bonded wearing course as a preservation treatment on jointed concrete."

In 1979, after receiving her bachelor's and master's degrees and a PhD from the University of Texas at Arlington, Corley-Lay joined the university's civil engineering faculty and taught for several years. She worked at a geotechnical and materials testing firm in Dallas and at what is now the Texas A&M Transportation Institute before joining the Pavement Management Unit at North Carolina DOT in 1990.

"Research is more likely to be implemented if the potential users are part of the team."

Corley-Lay became head of the Pavement Management Unit in 2002. She guided the implementation of a pavement management system and helped develop a draft of the DOT's transportation asset management plan. She also facilitated the use of mechanistic–empirical (ME) pavement design and the evaluation of flexible and rigid pavement requirements for new locations, using the American Association of State Highway and Transportation Officials' (AASHTO's) Mechanistic–Empirical Pavement Design Guide.

Other major projects included performance reports on aggregate base course pavements, unbonded concrete overlays over continuously reinforced concrete pavements, and ultrathin bonded wearing courses on jointed concrete pavements, as well as nondestructive testing of pavements with a falling weight deflectometer. She performed evaluations of why pavements fail and explored ways to rehabilitate them.

"I made it a habit to participate fully in North Carolina DOT's system for submitting research needs statements—I kept a running file of research ideas that would come up in meetings or in reading," Corley-Lay notes. "It was a rare year when I did not submit three or four ideas."

Some research projects required collaborative thinking. For example, Corley-Lay wrote a series of research needs statements on various aspects of chip seal construction, design, and inspection. North Carolina DOT worked with North Carolina State University to implement the findings; as a result, all 14 of the agency's divisions have adopted the recommended chip gradation and number of coverages, and lightweight aggregate, polymer-modified emulsions, pneumatic tire rollers, and combination rollers are all now in use. A Research Pays Off article, "Chip Seals for Improved Pavement Preservation: North Carolina's Approach," written by Corley-Lay and colleague Dennis Wofford (*TR News*, September–October 2012) describes the collaboration.

"Research is more likely to be implemented if the potential users are part of the team," Corley-Lay observes. "By including bituminous supervisors in our chip seal projects, we were able to change specifications, processes, and equipment purchases. In addition, the students assigned to the research learned much from the 20-plus-year veterans."

Most changes and improvements are incremental, she notes: "The initial models for pavement ME design were to be off-the-shelf; however, work continues and models are being improved in areas like top-down cracking, reflection cracking, and characterization of unbound materials."

Corley-Lay has been involved in TRB for more than 28 years. She joined the Standing Committee on Engineering Behavior of Unsaturated Geomaterials in 1989, and in 1993, the standing committees on Design and Rehabilitation of Asphalt Pavements and on Design and Rehabilitation of Concrete Pavements, serving on both for many years. She is a member of the standing committees on Pavement Rehabilitation and on Pavement Management Systems and currently chairs the Standing Committee on Pavement Preservation.

"Each of these activities provides opportunities to develop ideas for research and topics for synthesis studies, webinars for sharing research findings, and practical workshops," she comments. Corley-Lay also is a member—and past chair—of the AASHTO Joint Technical Committee on Pavements and of the AASHTOware Task Force on Pavement ME Design.

"No research result is the last word. The sponsors of research have a responsibility to make sure the research is moving forward—that means making time to read quarterly reports and to ask questions about delays, budget, or process," Corley-Lay observes. "Research is a learning process, so not every research project will result in an implementable finding. When it doesn't, you can ask what else might work better."

Guiding and Deploying Transformational Technologies

TRB Hosts Partners in Research Symposium

KATHERINE KORTUM

New technologies—connected and automated vehicles (CAVs), shared mobility, alternative-fuel vehicles, satellite-based air traffic control, air and space innovations, big data, cybersecurity, the Internet of things, and 3-D printing—are rapidly gaining deployment in personal mobility services, smart infrastructure, freight supply chains, smart cities, data networks, and unmanned aerial systems.

Public agencies face challenges in facilitating technology deployment to meet such public policy objectives as improved safety, reduced congestion, enhanced sustainability, and economic development. Research can help both the public and private sectors deploy these technologies to meet the objectives successfully.

Bridging the Gap

In late October and early November 2016, the Transportation Research Board (TRB) convened the TRB Partners in Research Symposium: Transformational Technologies in Detroit, Michigan, in partnership with the National Cooperative Highway Research Program (NCHRP) and the Michigan Department of Transportation. More than 100 representatives of industry, government, and academia discussed partnerships to bridge the gap between advanced technologies and public policy.

Technology companies are disrupting the automotive industry. Many new companies are entering the transportation sector, both in services and in technology development. TRB, academic and research institutions, standards organizations, and industry and professional associations can assist with understanding and informing the needed policy developments through an accelerated, dynamic research agenda coupled with fast-track demonstrations and deployments.

The author is Senior Program Officer, TRB Studies and Special Programs.

PHOTO: EDANDERDIE, FLICKR

Google's self-driving car navigating the streets of Palo Alto, California.

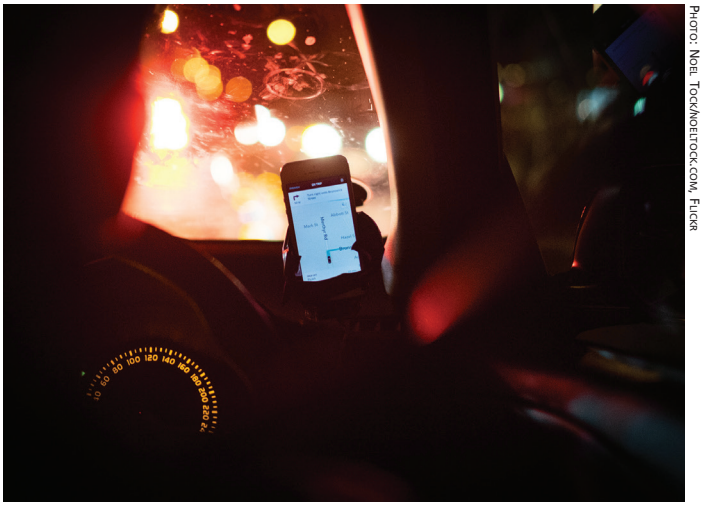


PHOTO: NOEL TOCK/NOETOCK.COM, FLICKR

New technologies, including ride-sourcing services like Uber, are presenting numerous challenges to public agencies on safety, congestion, sustainability, and economic development.

Research Roadmap

The symposium addressed the following questions to create a research roadmap and to facilitate government–industry partnerships:

- What are the most critical research needs for positive policy outcomes from the deployment of transformational technologies?
- Which of these needs are best addressed through public, private, and university partnerships?
- Given the rapid changes, can partnerships keep current with research needs?
- What form might these partnerships take, and what role can TRB and others play to facilitate partnerships?

Setting the Stage

Under the guidance of an organizing committee chaired by Susan Shaheen of the University of California, Berkeley, the symposium accommodated the perspectives of policy development and technology commercialization. The program addressed what policymakers need from industry, and what industry needs from policy makers.

The symposium built on previous TRB activities on innovative technologies in transportation, such as the TRB Executive Committee's Technology Task Force and NCHRP activities in policy development for CAVs and other transformational technologies. The Executive Committee task force had reviewed key transformational technologies and examined ways for TRB to contribute—for example, by convening roundtables for industry, government, and academia and strengthening research methods.

Balance and Partnerships

Attendance was balanced among representatives of government agencies, industry, and academia. Modalities such as rail, air, supply chains, warehousing, and real estate were represented, along with the disciplines of data science, alternative energy, travel behavior, urban science, and artificial intelligence. Participants from public and private highway transportation agencies also shared insights and perspectives.

Discussions revealed that the uncertainty raised by new technologies can discourage public–private collaboration and timely policy development. Some suggested that TRB could help reduce this uncertainty by bringing together public, private, and academic partners for accelerated research and policy advice, and by systematizing research questions and implementing a quick-response research process. Attendees noted that the new process must create a higher level of public–private trust and generate a willingness to share private data from public infrastructure technology users—that is, from model deployments.

PHOTO: UN GENEVA, FLICKR

Demonstration of an automated parking system.

High-Priority Research

Breakout discussions recommended six high-priority research projects for immediate action:

1. Scenarios for deployment of connected, automated, and shared vehicles. What are the forces driving the convergence of connectivity, automation, and the sharing economy, and what are the uses that will benefit? What are the barriers to these scenarios, and what are the impacts? Who are the main drivers for deployment, and what do they need to accelerate progress?

2. Public-sector support for the supply chain. How can technology contribute to connectivity in the supply chain? Comprehensive descriptions are needed for the necessary data sharing and management protocols, for the multimodal infrastructure investment, and for an operational decision support system, with a focus on freight corridors and on resolving bottlenecks.

3. Impact of mobility on demand (MoD) on the transportation system. How will MoD affect the transportation system? Are current transportation metrics and descriptors adequate to measure the transition? Research is needed to understand the impacts of MoD in such areas as equity; vehicle miles traveled, including induced demand; public transit; carbon dioxide and greenhouse gas emissions; and automobile ownership, occupancy, and parking. This will involve an understanding of temporal and spatial scales, the built environment, and land use.

PHOTO: SOUNDERBRUCE, FLICKR

An Amazon PrimeNow delivery car—high-tech innovations are affecting supply chains, retail delivery, and land use.

4. Impact of transformational technologies on land uses. Emerging technologies have transformed the last mile of retail delivery and have altered the demand for "brick and mortar" stores and distribution centers—as well as their characteristics. Research is needed to identify possible impacts on land uses from CAVs, MoD, and 3-D printing, including site selection and demand for retail, office, distribution, housing, parking, and production, as well as considerations for communities.

5. Framework for analyzing data from CAV pilots and from smart cities and communities for policy guidance. A framework for data from CAV pilots and initiatives for smart cities and communities could provide policy guidance. What are the lessons from model deployments and field tests? How may the data support changes to the *Manual on Uniform Traffic Control Devices* and other operational guidance? What do the data reveal about user expectations from CAV and vehicle-to-infrastructure technologies? How could these data support a policy primer for state and local decision makers, and what additional data should be collected from deployments?

6. Framework for data curation and standardized data sets. Data streams emanating from highly automated vehicles, as well as from CAV and smart cities trials, need a framework for consistent use and analysis. How can these data be combined with the static and dynamic data used in transportation? How can the diverse data sets of industry and government be combined, and how can proprietary data be protected?

For more information on the suggestions generated from this symposium, contact Mark Norman, TRB Director of Program Development and Strategic Initiatives, mnorman@nas.edu, or visit www.TRB.org/main/TransTech.aspx.

Conference Spotlights Pedestrian and Bicycle Safety

JENNIFER DILL

The author is Professor and Director, School of Urban Studies and Planning, Portland State University, Portland, Oregon; she chaired the planning committee for the University Transportation Centers 10th Spotlight Conference.

Interest in pedestrian and bicycle transportation is evident—cities and states have adopted policies and plans and are building more infrastructure, such as protected bike lanes. Research on these topics also has increased, from fewer than 10 peer-reviewed papers per year in the 1970s and 1980s, to more than 120 per year starting in 2012.

One trend, however, is not positive—safety. From 2005 to 2015, the number of fatal crashes involving pedestrians and bicycles nationwide remained largely stable but increased in 2015. In contrast, the total number of traffic crashes dropped considerably.

These positive and negative trends shaped the program for the 10th University Transportation Centers (UTC) Spotlight Conference, held at the National Academies' Keck Center, December 1–2, 2016. Sponsored by the UTC Program of the Office of the Assistant Secretary for Research and Technology, U.S. Department of Transportation (DOT), and organized by TRB, the conference focuses on a different topic each year.

PHOTO: SAN FRANCISCO BICYCLE COALITION, FLICKR

A bicyclist signals in San Francisco, California. Pedestrian and bicycle safety is an emerging priority.

Timely Topic

The 2016 theme, Pedestrian and Bicycle Safety, was timely—in its recently released *Strategic Agenda for Pedestrian and Bicycle Transportation*, the Federal Highway Administration (FHWA) adopted the goals of "an 80 percent reduction in pedestrian and bicycle fatalities and serious injuries within 15 years and a 100 percent reduction…within 20 years." Achieving these goals would require new strategies backed by research. The spotlight conference advanced practice-relevant research with the following aims:

◆ Share research needs and findings between university researchers, U.S. DOT staff, and transportation practitioners;

PHOTO: NEW YORK CITY DEPARTMENT OF TRANSPORTATION, FLICKR

Bicyclists at a traffic light on a busy street in Brooklyn, New York. More cities and states are investing in pedestrian and bicycle transportation infrastructure.

◆ Articulate the gaps in knowledge to define specific research needs; and

◆ Foster ongoing collaboration between universities and practitioners.

The spotlight topic clearly resonated, attracting more than 120 abstracts for poster presentations and a capacity attendance of more than 140.

In-Depth Studies

In the opening session, T. Bella Dinh-Zarr, Vice Chair of the National Transportation Safety Board, explained that pedestrian and bicycle safety is a relatively new priority for the agency, which has undertaken in-depth case studies of fatal crash events to develop safety recommendations. Robert Schneider of the University of Wisconsin, Milwaukee, presented data on fatal crash rates in metropolitan areas, identifying the contributions of such factors as traditional engineering, education, enforcement, activity levels, environmental and social contexts, emergency response, and age and other personal characteristics.

Reviewing the literature, Kari Watkins of Georgia Tech concluded that most pedestrian and bicycle treatments lack the rigorous research for sound design decisions. Although most practitioners identified safety as a high priority, she found that less than 30 percent conducted before-and-after studies of the treatment they installed.

New Data and Perspectives

Four plenary sessions covered design policy and guidance, emerging technologies, behavior change, and equity. In each session, the speakers challenged the audience with new data and perspectives.

Bill Schultheiss of Toole Design traced the history of guidance on pedestrian and bicycle infrastructure and urged the audience to "design death out of our system." Bob Scopatz of VHB shared early findings from a study by the National Highway Traffic Safety Administration showing high rates of distraction among pedestrians and drivers. David Schwebel of the University of Alabama, Birmingham, and Laura Sandt of the University of North Carolina Highway Safety Research Center explored the efficacy of interventions and highlighted the need to understand the psychology behind decision making by pedestrians, bicyclists, and drivers.

In the session on equity, Carniesha Kwashie of the Mayor's Fund for Philadelphia challenged the audience to diversify the profession, as well as the decision-making process. Charles Brown of Rutgers University shared research about the perceptions of bicycle safety among Black and Hispanic residents of New York and New Jersey, and Anthony Stephens of the American Council of the Blind described the challenges of the visually impaired.

PHOTO: LEA CAMARDA, TRB

Jeffrey LaMondia of Auburn University moderates a UTC conference plenary session on cycling and pedestrian equity.

Moving Forward

Six concurrent breakout sessions provided opportunities for university researchers and practitioners to exchange information and identify research priorities and opportunities for collaboration. The groups reported back on the needs for commonalities in research: for more exposure data of better quality; for collaboration and multidisciplinary perspectives; for evidence about interventions; for systematic approaches for varying contexts; and for tying research to practice.

The conference steering committee aimed for the two-day event to lead to action. TRB plans to post presentations (see www.trb.org/Calendar/Blurbs/174017.aspx) and to publish a summary of the conference. Follow-up work by FHWA and TRB standing committees is under way to move some of the research ideas forward.

PHOTO: CHRISTOPHER BURNS, UNSPLASH

Pedestrians cross Seventh Avenue in New York City. Research is exploring decision making by pedestrians.

Exploring the Nexus of Mobility and Communications on an Ocean Crossing

The Chan Wui & Yunyin Rising Star Workshop

KATHERINE KORTUM

In July 2016, TRB piloted a workshop in an unusual location—a transatlantic cruise on the *Queen Mary 2*. The Chan Wui & Yunyin Rising Star Workshop convened an accomplished group of academics to explore research at the nexus of mobility and communications and to discuss best professional practices.

The workshop offered two tracks. Junior fellows, or Rising Stars, comprised the majority of the participants. The Rising Stars were early-career academics working in transportation fields, each with one to three years of postdoctoral experience. The second track was for senior fellows—senior transportation academics with at least 30 years of academic experience.

Applications for junior and senior fellows came from around the world. An anonymous sponsor underwrote all expenses for the workshop and for each fellow's travel. The five junior fellows and two senior fellows came from four countries and two continents: Candace Brakewood, City College of New York; Yupo Chan, University of Arkansas at Little Rock; Greg Erhardt, University College London; Ke Han, Imperial College London; Eric Miller, University of Toronto; Rolf Moeckel, Technical University of Munich; and Rajesh Paleti, Old Dominion University.

Launching the Workshop

The anonymous sponsor of the Rising Star Workshop approached TRB in 2013 and provided funding and general guidance; TRB staff developed a plan to accomplish the sponsor's vision. Workshop announcements were distributed widely, starting in summer 2015, with the deadline for applications in late fall 2015.

TRB staff and a group of volunteer advisers reviewed the applications and chose seven outstanding candidates in early 2016. That spring, the seven fellows participated in regular planning sessions with TRB staff to ensure fruitful discussions onboard.

The workshop took place July 6–13, 2016, during a transatlantic crossing on the *Queen Mary 2* of the Cunard Cruise Line. The ship sailed from Brooklyn, New York, to Southampton, United Kingdom, without intermediate stops, providing time for in-depth technical and career discussions, a sheltered environment that encouraged a focus on the workshop goals, and an informal atmosphere that facilitated networking.

Although the research discussions focused on telecommunications, the ship itself had no cellphone service and limited Internet—participants disconnected temporarily from their regular responsibilities to focus on the workshop. Immersion in a workshop is a rare experience today—as Eric Miller commented, "Being locked up is good."

The author is Senior Program Officer, TRB Studies and Special Programs, and served as staff adviser to the workshop.

Rajesh Paleti, Assistant Professor, Civil and Environmental Engineering, Old Dominion University, explains his modeling technique to workshop participants.

The setting also allowed participants to take advantage of the many opportunities available onboard a luxury cruise ship. By the end of the week, the fellows had established relationships, both socially and professionally, that will continue long beyond the one-week voyage.

Workshop Goals

The Rising Star Workshop had two distinct goals. First was to host a series of in-depth discussions among the junior and senior fellows about critical research questions stemming from changes in transportation and telecommunications. Participants framed the policy issues, identified emerging research, assessed the quantitative relationships to be explored, discussed applicable data, and proposed new analytical techniques. Both junior and senior fellows presented their research ideas to the group and discussed potential avenues for solo work and research partnerships.

The workshop's second goal was for the senior fellows to provide advice and guidance to the junior fellows on the skills essential for success in academic careers. The career development discussions covered such topics as identifying emerging professional issues, developing contacts and peer networks, refining personal and communications skills in the workplace and in the classroom, and promoting and obtaining research support.

Contemporary career building requires skills that extend beyond an individual's technical expertise. Some young professionals may find mentors who invest the time to discuss not only technical issues but career paths and planning. Many other young professionals, however, struggle to find trusted advisers, and the lack of timely advice may limit their academic careers.

Workshop Results

Junior fellows learned how to formulate a plan to guide their future research and career activities and gained a deeper understanding of the factors for career success, both in the classroom and in the research arena. The group discussions included time management strategies, both for their own research and for working with students. Senior fellows provided advice on changing institutions, handling problem students, teaching virtually, presenting at conferences, and choosing journals for paper submissions based on the paper topic and audience.

The senior fellows built strong connections with a talented group of young academics and potential research collaborators. Through their interactions with the five junior fellows, the two senior fellows gained new understandings of the challenges that young academics face and insights for mentoring younger colleagues to respond effectively to these challenges.

Both sets of fellows strengthened their understandings of the history of mobility and communications. They also gained a stronger sense of the future directions of research in this area and strong connections to a new-found peer group.

Workshop Follow-Up

As a follow-up to the workshop, each of the seven fellows authored a paper describing his or her own research; the papers underwent rigorous peer review and will be published in the 2017 series of the *Transportation Research Record: Journal of the Transportation Research Board*. Topics include a synthesis of past research, an assessment of the effects of technological advances on mobility and communications, an exploration of the ways that advances will change research needs and the conduct of research, and a description of future research directions.

The workshop participants enjoyed the chance to interact informally on a luxury cruise with high-achieving peers who face similar issues. Fellows described the workshop as a safe place to explain "half-baked research ideas" and gain "nonjudgmental career advice."

One junior fellow may have summarized the aim of the workshop when he told another: "I'd be keen to see what data you have and how I can help you build off of it." Collaboration is a desired outcome of all TRB convening activities, and the Chan Wui & Yunyin Rising Star Workshop has piloted a new course to that success.

Rising Star workshop participants on board the *Queen Mary 2* (*left to right:*) Rajesh Paleti, Old Dominion University; Rolf Moeckel, Technical University of Munich; Greg Erhardt, University College London; Candace Brakewood, City College of New York; Katherine Kortum, TRB; Yupo Chan, University of Arkansas at Little Rock; Eric Miller, University of Toronto; and Ke Han, Imperial College London.

New Leader for Editorial Board

Christine L. Gerencher, TRB Senior Program Officer for Aviation and Environment, has succeeded Frederic D. Hejl as Chair of the *TR News* Editorial Board, a staff committee with representatives from each division of TRB, charged with developing the bimonthly magazine's content, recruiting authors, and reviewing and scheduling articles. Gerencher has served on the editorial board since 2009 and has developed and coordinated two theme issues on aviation research, assisted on several others—including an issue on adaptations to climate change—and has contributed cover and feature photographs.

Hejl retired from TRB in May 2016 but agreed to continue as editorial board chair until the end of that year. He was appointed to the editorial board in 1993 by then–Executive Director Thomas B. Deen and earned the title of "father of the theme issue" for his advocacy and expertise in developing topic-focused collections of feature articles. He was named chair in January 2009 and contributed to the guidance of nearly 150 issues of TRB's magazine during his tenure as member and chair.

Newly appointed as members of the *TR News* Editorial Board were Karen S. Febey, Senior Report Review Officer, and Nelson H. Gibson, Senior Program Officer, Materials and Construction.

Photo: Nick Gass, TRB

Gerencher chairs the February meeting of the TR News *Editorial Board.*

PHOTO: CLAIRE DENESOVYCH, FLICKR

Bears congregate near a highway. Researchers with the Western Transportation Institute focused on the effectiveness of mitigation measures in reducing collisions with large mammals and the use of crossing structures.

Protecting Wildlife on Montana Roads

The reconstruction of a 56-mile-long section of US-93 on the Flathead Indian Reservation in northwest Montana is one of the most extensive wildlife-sensitive highway design efforts in North America. The project includes the installation of 39 wildlife crossing structures and nearly 9 miles of roadside wildlife exclusion fences.

Western Transportation Institute researchers conducted studies between 2002 and 2015, focusing on the effectiveness of the mitigation measures in reducing collisions with large mammals and the use of crossing structures by white-tailed deer, mule deer, and black bear.

According to research data, wildlife fences installed along 3.1 miles or more of roadway reduced collisions with large mammals by more than 80 percent. Wildlife fences less than 3.1 miles in length were approximately 50 percent effective on average and were highly unpredictable.

Collisions often occurred at or near the ends of the shorter fences,. Fence end treatments, such as electric mats embedded in the pavement, can improve the effectiveness of these fences. Researchers found, however, that the treatments did not reduce vehicle collisions with black bear and grizzly bear, because of fence gaps and the shorter fence lengths. After the reconstruction of US-93, wildlife cameras monitored 29 crossing structures and recorded more than 95,000 successful crossings—nearly 22,650 successful crossings per year, with 69 percent by white-tailed deer. Mule deer and domestic dogs and cats each represented approximately 5 percent of the successful crossings, and black bear crossed successfully 1,531 times.

Certain species preferred certain types of crossings: white-tailed deer favored bridges, overpasses, and large culverts; mule deer also used bridges and large culverts; black bear crossed a wider variety of structures; grizzly bears preferred large culverts; and elk and moose took the wildlife overpass. Data also showed that the mitigation measures maintained or improved habitat connectivity for deer and black bear.

For more information, visit www.mdt.mt.gov/other/webdata/external/research/docs/research_proj/wildlife_crossing/phaseii/PHASE_II_FINAL_REPORT.pdf.

Safety Designs for Cyclists on High-Speed Roads

Cyclists on high-speed roadways face serious risks without sufficient separation from the motor vehicle traffic, according to research conducted for the Maryland State Highway Administration. The study investigated bicycle infrastructure design options and treatments to facilitate the safe accommodation of cyclists on high-speed roadways in Maryland.

Researchers reviewed U.S. and international best practices and bicycle infrastructure design options and solicited opinions and suggestions from bicycle groups in 16 states. These suggestions included colored pavements in conflict areas and designs that account for the way that cyclists use the facilities—for example, experienced cyclists make turns differently, depending on the traffic volumes.

The report proposes a "rumble-buffered" bike lane that has a minimum width of 10 feet, including 5 feet for a rumble-strip buffer and 5 feet for a bike travel lane. The rumble-buffered bike lane could be constructed from the available paved roadside shoulder, according to the report.

For more information, visit www.roads.maryland.gov/OPR_Research/MD-16-SHA-UM-4-06_Bicycles-on-High-Speed-Roadways_summary.pdf.

PHOTO: MIKE JUVRAD, FLICKR

Bicyclist travels along a high-speed roadway on a rumble strip–buffered bike lane.

CALENDAR

TRB Meetings

March

20–23 10th International Conference on Managing Fatigue
San Diego, California

April

4–7 2017 Joint Rail Conference*
Philadelphia, Pennsylvania

10–12 International Congress on Transport Infrastructure and Systems*
Rome, Italy

25–27 11th International Bridge and Structures Management Conference
Mesa, Arizona

May

1 TRB Workshop at the 68th Highway Geologists Symposium
Marietta, Georgia

8–10 5th International Conference on Roundabouts
Green Bay, Wisconsin

11–12 Ferry Safety and Technology Conference*
New York, New York

14–18 16th TRB National Transportation Planning Applications Conference
Raleigh, North Carolina

14–18 International Conference on Ecology and Transportation*
Salt Lake City, Utah

17–18 Innovations in Freight Data Workshop
Irvine, California

21–24 5th Urban Street Symposium*
Raleigh, North Carolina

June

4–6 1st World Transport Convention*
Beijing, China

4–8 3rd North American Symposium on Landslides*
Roanoke, Virginia

9–12 International Conference on Transportation Infrastructure and Materials*
Qingdao, China

12–15 1st International Roadside Safety Conference: Safer Roads, Saving Lives, Saving Money
San Francisco, California

14–17 Workshop on Future *Highway Capacity Manual* Updates
Minneapolis, Minnesota

28–30 10th International Conference on the Bearing Capacity of Roads, Railways, and Airfields*
Athens, Greece

July

6–7 3rd International Symposium on Transportation Soil Engineering in Cold Regions
Guide, Qinghai, China

11–13 Automated Vehicles Symposium 2017*
San Francisco, California

15–19 GeoMEast International Conference: Innovative Infrastructure Geotechnology*
Sharm El-Sheikh, Egypt

23–26 Transportation-Related Noise and Vibration Committee Summer Conference
Minneapolis, Minnesota

24-26 22nd International Symposium on Transportation and Traffic Theory*
Evanston, Illinois

27–28 8th International Visualization in Transportation Symposium: Visualization in Action
Washington, D.C.

30–Aug. 2 56th Annual Workshop on Transportation Law
Salt Lake City, Utah

TBD Historic and Archeological Preservation in Transportation Committee Summer Conference 2017
Minneapolis, Minnesota

TBD Resource Conservation and Recovery Summer Conference
Duluth, Minnesota

August

21–22 9th New York City Bridge Conference*
New York, New York

22–25 16th Biennial Asilomar Conference on Transportation and Energy*
Pacific Grove, California

27 American Society of Civil Engineers 2017 International Conference on Highway and Airfield Technology
Philadelphia, Pennsylvania

September

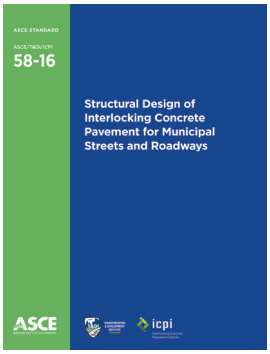
6–8 Transit GIS Conference
Washington, D.C.

Additional information on TRB meetings, including calls for abstracts, meeting registration, and hotel reservations, is available at www.TRB.org/calendar, or e-mail TRBMeetings@nas.edu.

*TRB is cosponsor of the meeting.

Structural Design of Interlocking Concrete Pavement for Municipal Streets and Roadways

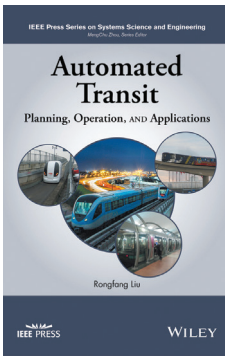
American Society of Civil Engineers (ASCE). 2016; 42 pp.; ASCE members, $60; nonmembers, $80; 978-0-784-41450-7.



Interlocking concrete pavers can provide a durable and effective pavement system, but proper design, construction, and maintenance procedures are required. This volume, which replaces the previous standard, establishes structural design guidelines for municipal streets and roadways. The new edition includes updated references to quoted ASTM standards, clarification of subgrade type and drainage characteristics, and more.

Automated Transit: Planning, Operation, and Applications

Rongfang Liu. Wiley–IEEE Press, 2016; 224 pp.; $99.95; 978-1-118-89100-1.



This book analyzes the successful implementation of automated transit in major international cities such as Paris; Toronto, Canada; London; and Kuala Lumpur, Malaysia. The author, a member of the TRB Standing Committee on Automated Transit Systems, provides a thorough examination of automated transit applications, their impacts, and implications for society and offers information on planning, costs, and applications of automated transit systems.

The titles in this section are not TRB publications. To order, contact the publisher listed.

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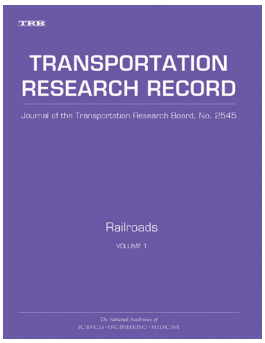


Railroads, Volumes 1–2

Transportation Research Records 2545–2546

Railroad topics are explored in these volumes, such as a case study in Washington State short-line railroads, two-train trajectory optimization with a green-wave policy, and an analysis of collision risk for U.S freight trains.

2016; Vol. 1: 139 pp.; TRB affiliates, $57.75; nonaffiliates, $77; Vol. 2: 144 pp.; TRB affiliates, $51; nonaffiliates, $68; Subscriber categories: Vol. 1: railroads, design and construction, safety and human factors; Vol. 2: railroads, freight transportation, passenger transportation.

Freight Systems, Volumes 1–2

Transportation Research Records 2547–2548

Among the topics presented are an analysis of truck platooning strategies, an economic analysis of cargo cycles for urban mail delivery, food rescue and delivery, and implementing freight fluidity in the state of Maryland.

2016; Vol. 1: 120 pp.; TRB affiliates, $51; nonaffiliates, $68; Vol. 2: 116 pp.; TRB affiliates, $51; nonaffiliates, $68. Subscriber categories: Vol. 1: freight transportation, motor carriers, planning and forecasting; Vol. 2: freight transportation, terminals and facilities.

Marine Transportation and International Trade

Transportation Research Record 2549

Developing a port energy management plan, a payback period for emissions abatement alternatives, and an analysis of profitability for container shipping in the Arctic are among the topics explored in this volume.

2016; 110 pp.; TRB affiliates, $51; nonaffiliates, $68. Subscriber categories: marine transportation; freight transportation; safety and human factors.

Maintenance and Preservation

Transportation Research Record 2550

Authors present findings on a practical tool for prioritizing rehabilitation and preventive maintenance in pavements, the potential influences on long-term service performance of road infrastructure

The TRR Online website provides electronic access to the full text of more than 15,000 peer-reviewed papers that have been published as part of the Transportation Research Record: Journal of the Transportation Research Board *(TRR) series since 1996. The site includes the latest in search technologies and is updated as new TRR papers become available. To explore TRR Online, visit www.TRB.org/TRROnline.*

TRB PUBLICATIONS *(continued)*

by automated vehicles, the management of bridges under aging mechanisms and extreme events, and more.

2016; 140 pp.; TRB affiliates, $54; nonaffiliates, $72. Subscriber categories: maintenance and preservation, bridges and other structures, pavements.

Maintenance Services; Transportation Weather; and Winter Maintenance
Transportation Research Record 2551

A connected vehicle solution for winter road surface condition monitoring, the use of social media by transportation agencies for traffic management, and assessing driver speed choice in fog are among the subjects examined.

2016; 156 pp.; TRB affiliates, $60.75; nonaffiliates, $81. Subscriber categories: maintenance and preservation, operations and traffic management, vehicles and equipment.

Research and Education 2016
Transportation Research Record 2552

Authors present information on negotiating a financial package for freeways, developing asynchronous online training for transportation agency professionals, millennials in the transportation workforce, and more.

2016; 56 pp.; TRB affiliates, $45.75; nonaffiliates, $61. Subscriber categories: research, education and training.

Highway Capacity and Quality of Service
Transportation Research Record 2553

Simulation guidance for the calibration of freeway lane closure capacity, an exploratory study on the correlation between Twitter concentration and traffic surges, and a conceptual approach for estimating dynamic passenger car units using simultaneous equations are among the topics explored in this volume.

2016; 168 pp.; TRB affiliates, $60.75; nonaffiliates, $81. Subscriber categories: operations and traffic management, planning and forecasting.

Freeway Operations
Transportation Research Record 2554

The subjects examined include a regional evaluation of bus rapid transit with and without transit signal priority, a life-cycle benefit–cost analysis framework for ramp-metering deployments, and modeling traffic incident duration using quantile regression.

2016; 184 pp.; TRB affiliates, $63.75; nonaffiliates, $85. Subscriber categories: operations and traffic management, safety and human factors.

Visibility and Work Zone Traffic Control
Transportation Research Record 2555

Examined are the safety effects of portable end-of-queue warning system deployments at Texas work zones, the impact of advisory signs on vehicle speeds in highway nighttime paving project work zones, an assessment of an adaptive driving beam headlighting system, and other subjects.

2016; 119 pp.; TRB affiliates, $53.25; nonaffiliates, $71. Subscriber categories: operations and traffic management, safety and human factors.

Operational Effects of Geometrics and Access Management
Transportation Research Record 2556

Roundabouts as a form of access management, site-specific safety analysis of diverging diamond interchange ramp terminals, and maintenance of traffic for innovative geometric design work zones are among the topics explored in this volume.

2016; 108 pp.; TRB affiliates, $51.75; nonaffiliates, $69. Subscriber category: operations and traffic management.

Effective Project Scoping Practices to Improve On-Time and On-Budget Delivery of Highway Projects
NCHRP Report 821

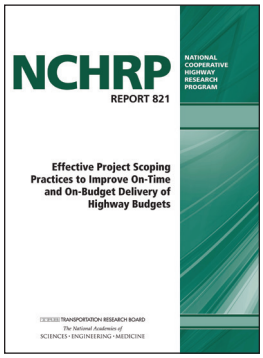
This guidebook demonstrates how a state department of transportation (DOT) can enhance its scoping process to produce a project cost estimate and schedule that facilitate programming decision making and improve accountability.

2016; 188 pp.; TRB affiliates, $57.75; nonaffiliates, $77. Subscriber categories: highways, design, planning and forecasting.

Evaluation and Assessment of Environmentally Sensitive Stream Bank Protection Measures
NCHRP Report 822

This report evaluates and assesses guidelines for the design, installation, monitoring, and maintenance of environmentally sensitive stream bank stabilization and protection measures and develops quantitative engineering design guidance for selected treatments.

2016; 264 pp.; TRB affiliates, $63; nonaffiliates, $84. Subscriber categories: environment, hydraulics and hydrology.



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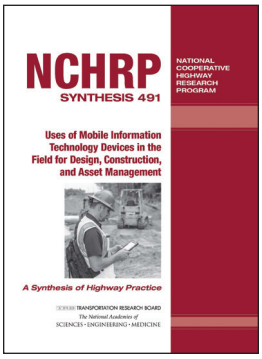
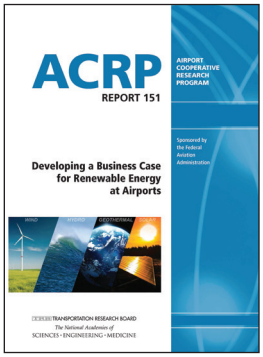


Uses of Mobile Information Technology Devices in the Field for Design, Construction, and Asset Management
NCHRP Synthesis 491

Summarized in this volume are the types of fibers used in asphalt mixtures, their properties, how they are tested, how they are applied, and their lab and field performance.

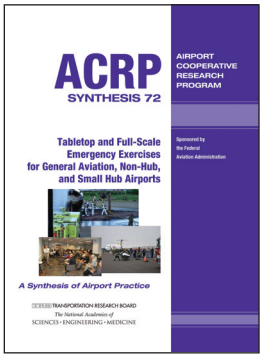
2016; 113 pp.; TRB affiliates, $48; nonaffiliates, $64. Subscriber categories: construction, data and information technology, design, highways.



Performance Specifications for Asphalt Mixtures
NCHRP Synthesis 492

This synthesis provides examples of engineering tools for the development and implementation of performance specifications for asphalt mixtures, examples of the contents of the specifications, and more.

2016; 92 pp.; TRB affiliates, $45.75; nonaffiliates, $61. Subscriber categories: highways, geotechnology, materials, pavements.



Developing a Business Case for Renewable Energy at Airports
ACRP Report 151

This report provides instructions and tools for airport managers evaluating proposed renewable energy projects and their alternatives, to assist in making informed energy decisions for financial, sustainability, environmental, and social benefits.

2016; 168 pp.; TRB affiliates, $53.25; nonaffiliates, $71. Subscriber categories: aviation, energy, finance.

Evaluating Methods for Determining Interior Noise Levels Used in Airport Sound Insulation Programs
ACRP Report 152

Authors offer guidance in selecting and implementing measures of noise levels in dwellings covered by airport noise insulation programs. This report complements ACRP Report 89; *Guidelines for Airport Sound Insulation Programs*.

2016; 150 pp.; TRB affiliates, $53.25; nonaffiliates, $71. Subscriber categories: aviation, environment.

Tabletop and Full-Scale Emergency Exercises for General Aviation, Non-Hub, and Small Hub Airports
ACRP Synthesis 72

This synthesis offers tools and practices for emergency response operations at small airports. The report provides sample plans for exercises, a checklist of effective practices, and a road map for developing an effective exercise program.

2016; 146 pp.; TRB affiliates, $53.25; nonaffiliates, $71. Subscriber categories: aviation, security and emergencies.

Bus Operator Workstation Design for Improving Occupational Health and Safety
TCRP Report 185

Offered in this volume is guidance for integrating new technologies into current procurement practices and for improving bus operator workstation design across the transit industry. The report includes guidelines to update TCRP Report 25, *Bus Operator Workstation Evaluation and Design Guidelines*, as well as a digital model for a bus operator workstation.

2016; 126 pp.; TRB affiliates, $18.75; nonaffiliates, $25. Subscriber category: public transportation.

Economic Impact Case Study Tool for Transit
TCRP Report 186

Authors present the results of a project to create the prototype for a searchable, web-based database of public transit investment projects and their associated, transit-driven economic and land development outcomes.

2016; 81 pp.; TRB affiliates, $15; nonaffiliates, $20. Subscriber category: public transportation.

Transit-Supportive Parking Policies and Programs
TCRP Synthesis 122

This synthesis documents transit agency parking policies and parking management at transit stations, using three primary resources: a scan of research on transit-supportive parking policies, an original survey of transit agencies, and brief agency profiles based on interviews and available data.

2016; 69 pp.; TRB affiliates, $15; nonaffiliates, $20. Subscriber categories: policy, public transportation, society, terminals and facilities.

Guidebook for Intercity Passenger Rail Service and Development
NCRRP Report 6

This report presents the resources, strategies, analytical tools, and techniques to support all phases of planning and decision making in the development of intercity passenger rail service at state, regional, and multistate levels.

2016; 174 pp.; TRB affiliates, $53.25; nonaffiliates, $71. Subscriber categories: administration, passenger transportation, railroads.

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FEATURES are timely articles of interest to transportation professionals, including administrators, planners, researchers, and practitioners in government, academia, and industry. Articles are encouraged on innovations and state-of-the-art practices pertaining to transportation research and development in all modes (highways and bridges, public transit, aviation, rail, marine, and others, such as pipelines, bicycles, pedestrians, etc.) and in all subject areas (planning and administration, design, materials and construction, facility maintenance, traffic control, safety, security, logistics, geology, law, environmental concerns, energy, etc.). Manuscripts should be no longer than 3,000 words (12 double-spaced, typed pages). Authors also should provide charts or tables and high-quality photographic images with corresponding captions (see Submission Requirements). Prospective authors are encouraged to submit a summary or outline of a proposed article for preliminary review.

RESEARCH PAYS OFF highlights research projects, studies, demonstrations, and improved methods or processes that provide innovative, cost-effective solutions to important transportation-related problems in all modes, whether they pertain to improved transport of people and goods or provision of better facilities and equipment that permits such transport. Articles should describe cases in which the application of project findings has resulted in benefits to transportation agencies or to the public, or in which substantial benefits are expected. Articles (approximately 750 to 1,000 words) should delineate the problem, research, and benefits, and be accompanied by one or two illustrations that may improve a reader's understanding of the article.

NEWS BRIEFS are short (100- to 750-word) items of interest and usually are not attributed to an author. They may be either text or photographs or a combination of both. Line drawings, charts, or tables may be used where appropriate. Articles may be related to construction, administration, planning, design, operations, maintenance, research, legal matters, or applications of special interest. Articles involving brand names or names of manufacturers may be determined to be inappropriate; however, no endorsement by TRB is implied when such information appears. Foreign news articles should describe projects or methods that have universal instead of local application.

POINT OF VIEW is an occasional series of authored opinions on current transportation issues. Articles (1,000 to 2,000 words) may be submitted with appropriate, high-quality illustrations, and are subject to review and editing.

BOOKSHELF announces publications in the transportation field. Abstracts (100 to 200 words) should include title, author, publisher, address at which publication may be obtained, number of pages, price, and ISBN. Publishers are invited to submit copies of new publications for announcement.

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- All manuscripts should be supplied in 12-point type, double-spaced, in Microsoft Word, on a CD or as an e-mail attachment.
- Submit original artwork if possible. Glossy, high-quality black-and-white photographs, color photographs, and slides are acceptable. Digital continuous-tone images must be submitted as TIFF or JPEG files and must be at least 3 in. by 5 in. with a resolution of 300 dpi. A caption should be supplied for each graphic element.
- Use the units of measurement from the research described and provide conversions in parentheses, as appropriate. The International System of Units (SI), the updated version of the metric system, is preferred. In the text, the SI units should be followed, when appropriate, by the U.S. customary equivalent units in parentheses. In figures and tables, the base unit conversions should be provided in a footnote.

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